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ABSTRACT

The purpose of the activities presented in this guide is to develop awareness among middle school students of the Great Lakes, particularly Lake Erie. Activity topics include Lake Awareness, Human Activities, Shore Processes, and Shoreline Clean-up. The appendix includes Coastweek 1995 Reference Information. (YDS)

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Lakers Observe Coastweeks:

A Manual of Classroom & Coastal Activities for Middle Schools

A cooperative project of the

Ohio Lake Erie Commission

and the

Ohio Sea Grant Education Program.

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LAKERS* Observe Coastweeks

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Lake-Aware Kids Engaged in Relevant Science (LAKERS) Coastweeks Activity Guide

Produced by the Ohio Sea Grant Education Program
for the Ohio Lake Erie Commission

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LAKERS* Observe Coastweeks

[*Lake-Aware Kids Engaged in Relevant Science]

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Introduction

Coastweeks is an international program sponsored by the Center of Marine Conservation (CMC) in Washington, D.C. It is celebrated during a three week time period, usually from mid-September through the first part of October. Volunteers participate in a variety of projects that might include environmental awareness, beach clean-up, water conservation, or surveying boaters or fishers. Data from beach clean-up projects are recorded on specific forms, compiled by a state coordinator and sent to the CMC for dissemination in print and electronic forms. Hundreds of thousands of kilograms of beach litter have been safely collected and properly disposed of since the program began in 1984 (1991 in Ohio).

A few of the places in Ohio where beach clean-ups have occurred are Cleveland, Toledo, and an underwater project in Put-in-Bay.

Purpose of this packet

This packet of materials has been assembled for middle school teachers to use in their classrooms. The activities will heighten students' awareness of the Great Lakes, particularly Lake Erie, and can act as a springboard for students to become **LAKERS** (Lake-Aware Kids Engaged in Relevant Science). The activities involve students in group and individual work using a "hands-on" approach to discover ways in which humans use the lakes, benefit from them, and in turn affect the environment in and along Lake Erie.

This set of materials can prepare students for a class excursion to the shore. During such an excursion, students can identify what they find there, discuss the geological and human sources of the things they find, explore the processes that change the beach over a period of time, and do a beach clean-up activity that leads to an examination of the litter found and its proper disposal. Any or all of these activities may be done.

Materials in this manual are also useful even if a trip to the shore is not possible. Most of the activities have been selected from larger units in their subject area. The authors hope teachers will use additional Lake Erie teaching materials they encounter through Coastweeks experiences.

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Rationale: Earth Systems Education

LAKERS activities are based on the Framework of Understandings that all students should acquire in their science education. The development of this framework started in 1988 with a conference of educators and scientists and culminated in the Program for Leadership in Earth Systems Education. It is intended for use in the development of integrated science curricula. The framework represents the efforts of some 200 teachers and scientists. Support was received from the National Science Foundation, The Ohio State University, and the University of Northern Colorado.

The seven Understandings are listed here, and a poster is available from Ohio Sea Grant Education ($2) to illustrate them. For further information on Earth Systems Education, contact the Earth Systems Education Program Office, 2021 Coffey Road, The Ohio State University, Columbus, OH 43210. Our Internet address is http://earthsys.ag.ohio-state.edu/

UNDERSTANDING #1: Earth is unique, a planet of rare beauty and great value.

UNDERSTANDING #2: Human activities, collective and individual, conscious and inadvertent, affect earth systems.

UNDERSTANDING #3: The development of scientific thinking and technology increases our ability to understand and utilize earth and space.

UNDERSTANDING #4: The earth system is composed of the interacting subsystems of water, rock, ice, air, and life.

UNDERSTANDING #5: Earth is more than 4 billion years old, and its subsystems are continually evolving.

UNDERSTANDING #6: Earth is a small subsystem of a solar system within the vast and ancient universe.

UNDERSTANDING #7: There are many people with careers and interests that involve study of earth's origin, processes, and evolution.

Objectives of the activity set

Students who complete several activities in the combined set of materials (in-class and shoreline) will

- acquire knowledge about the importance of the Lake Erie environment for human uses and for natural ecosystem functions,
- learn about the ecology of the lake and how humans fit into the ecosystem,
- develop ability to collect data to answer important questions about the coast,
- be aware of some impacts of humans on the environment, and
- develop a stewardship attitude that will foster their growing role in Lake Erie protection.

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Contents and Activity Descriptions

The activities included come mainly from the Ohio Sea Grant Education Program at Ohio State. They have been grouped into four topics. Additional relevant activities are available from Ohio Sea Grant in the publications referenced below. A brief description of each activity follows. The sequence of activity descriptions implies a suggested order in which the activities could be used. Not all of the activities must be done. You may know of other excellent resources you wish to use along with or instead of some of these activities.

Possible ways to link activities and to expand them using the Internet are included along with the activity descriptions.

TOPIC 1 - LAKE AWARENESS

How Big is a Crowd? p. 9

from **Great Lakes Environmental Issues**, 1997, Ohio Sea Grant, page 15.

This activity explores how Lake Erie is different from the other Great Lakes in terms of size, and the fish and human populations around it. Students discover the things that make Lake Erie unique and special. Teachers should point out that these things also make Lake Erie particularly vulnerable to abuse. Many people can recall the result of the draining of large amounts of phosphates from detergents into Lake Erie in the 1960s and the resultant algae blooms and fish kills. Lake Erie also recovers from such past abuse fairly quickly for the same reasons. Since human population is high on the United States side of Lake Erie, it is appropriate to explore some ways in which humans use and have affected the lake.

Who is visiting the shore? p. 13

Coast activity

On the class visit to the shore, do a census or sample of the people there and how they are using the shore.

How does the estuary serve as a nursery? p. 15

from **Life in the Great Lakes**, 1997, Ohio Sea Grant, page 105.

Complex interactions within a Lake Erie estuary are explored. Possible human impact on such a valuable ecosystem is discussed.

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TOPIC 2 - HUMAN ACTIVITIES

One way in which humans have affected Lake Erie is to use it for transportation. The effects are not only related to population issues but also to the debris and other coastal impacts from boats of all kinds.

Where go the boats? p. 23

from **Great Lakes Shipping**, 1997, Ohio Sea Grant, page 25.

In this activity, students discover the value of Toledo as a port. Other kinds of boats that use the Great Lakes are identified in the coastal activity that follows.

What kinds of boats come to this area of the coast? p. 33

Coast activity

In investigative groups, students learn about cargo ships, charter fishing, recreational motor and sailboats, and passenger ferries. They contact people from these kinds of boats to find out how their operations protect water quality and prevent marine debris.

Lake Erie is an open system in terms of human use. Things can come in through many entry points: boat launches, surface streams, connecting channels, runoff, air, etc. This leads to the next activity about invader species that have moved in with human help. Students should begin to think about what comes into the lakes and how.

What do scientists know about invader species of the Great Lakes? p. 35

from **Life in the Great Lakes**. Ohio Sea Grant, 1997, page 41.

In this activity, students work in groups and use cards to learn about eight invader species, including where they came from, how they got here, and what problems they cause. They present what they have learned to the rest of the class. This is a good activity with which to use a jig-saw approach.

Zebra mussel shells are often found on Lake Erie beaches. How do they get there? What processes cause beaches to form? How does material get deposited on a beach?

How did it get here? [beach debris] p. 45

Coast activity

Students write the memoirs of a piece of beach debris, using their knowledge of natural coastal processes combined with human use of materials.

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What is the impact of beach debris? p. 46

adapted from *Visualizing Changes in the Earth System, Activity A,* from **Great Lakes Instructional Materials for the Changing Earth System,** Ohio Sea Grant, 1995, page 45.

Students will be able to summarize their knowledge of beach processes and the source of objects found on the beach and how they are a part of the bigger Earth system.

TOPIC 3 - SHORE PROCESSES

What evidence of glaciation and geologic processes can be found on Great Lakes beaches? p. 49

from **Land and Water Interactions in the Great Lakes,** Ohio Sea Grant, 1996, page 65.

Students identify rocks typically found on Lake Erie beaches. The variety of rocks found on a beach can be explained by glaciation and geology. Students begin to understand that the Lake Erie system has changed over time and is likely to continue doing so.

What causes the shoreline to erode? p. 53

from **Land and Water Interactions in the Great Lakes,** Ohio Sea Grant, 1996, page 73.

In this activity, students simulate the erosion of different types of shorelines. They also learn about longshore currents, which are the natural processes largely responsible for what is found on the beach.

How does debris move in surface water? p. 59

Coast activity with Internet

Students use wind diagrams and weather maps of Lake Erie from the Great Lakes Forecasting System to see how wind patterns can determine where beach debris items may appear and how fast they could travel.

How do the levels of the Great Lakes change? p. 63

from **Great Lakes Climate and Water Movement,** Ohio Sea Grant, 1996, page 57.

In this activity, students discover that lake levels are not constant over time, and the effects (i.e. flooding, erosion) that changing lake levels have along the shoreline. A global warming scenario is included.

How is today's weather related to the "big picture" of state and national weather? p. 70

Internet activity

Students examine wind patterns on Lake Erie for a recent day and relate them to the newspaper or on-line weather map to see how daily weather influences water movement in the lake.

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TOPIC 4 - SHORELINE CLEAN-UP

Does trash come up for air? What will people see on the long walk to the water's edge? p. 73

Adapted from **GLIMCES**, 1995. *Visualizing changes in the Earth system.* Ohio Sea Grant. p. 48.

Scientists predict that global climate change will result in much less water in the Great Lakes region. Lake levels may drop as much as 1.3 meters! If new beach is exposed, what will we see there?

What can we find on a Lake Erie beach? p. 74

Coast activity

In this scavenger hunt, students and teachers will find and identify objects and materials on a Lake Erie beach. Ways in which humans affect beaches are also explored.

Beach Sweep data forms from the Center for Marine Conservation p. 75

Coast activity

How does Lake Erie beach debris compare to that found in other areas? p. 77

Coast activity

After the clean-up activity, students count the various categories of litter they collected using data forms from the Center for Marine Conservation. They use the data to compare what they found to previous clean-up efforts and how "their" beach compares to Lake Erie beaches in general. Students also explain how they might be able to reduce the amount of litter on a beach.

How can beach finds be classified? p. 81

adapted from How does a dichotomous key work? in **Life in the Great Lakes**, 1997. Ohio Sea Grant, p. 15.

If reporting to national databases is not your goal, use the beach debris to meet state science standards in teaching students how to classify materials.

How long does it take to disappear? p. 83

Coast follow-up

If you did not remove the beach debris, how long would it take for certain types of materials to decompose? Compare your finds with the prospects for how the beach could look in one year, ten years, and longer.

How big is the problem of solid waste? p. 84

Coast follow-up

Gee-whiz data about throwaway patterns in the US!

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SAFETY ISSUES

If a beach clean-up is undertaken, students and adults are to follow these safety rules:

1. All persons will wear gloves (work gloves will suffice).
2. Only adults pick up sharp objects.
3. All objects that are collected will be treated with care to ensure everyone's safety.
4. All students will stay in their designated areas.
5. No student will go into water unless directly supervised by an adult.

DISPOSAL ISSUES

Contact your local solid waste authority about what to do with collected materials. You may have to use vehicles to transport trash bags full of materials to a facility. Get them to come and pick things up, if you can. Explain to them what your project is about.

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How big is a crowd?

The Great Lakes and the surrounding land provide many resources for the people who live in the area. Water for drinking and industry, fish for food, minerals, and other resources are abundant. However, people change the landscape. They create wastes and add substances to the environment when they use resources. These can be harmful and long lasting. When many people are concentrated in one area, they may compete for resources. In addition, the wastes these people generate tend to concentrate in the area immediately around them and may cause pollution problems.

OBJECTIVES

When students have completed this activity, they will be able to:

- Compare the relative sizes of the five Great Lakes and their human populations.
- Describe some of the problems that arise when many people depend on a limited resource.

PRE-LAB

1. Cut lengths of string and tie the ends together to make loops proportional to the areas of the five Great Lakes. Suggested lengths in meters are given for groups of less than 30 and more than 30 participants.

String Lengths Needed

	Class Size	
	less than 30	**greater than 30**
Lake Superior	8.5m	11.0m
Lake Michigan	6.0m	7.5m
Lake Huron	6.0m	7.5m
Lake Erie	2.5m	3.0m
Lake Ontario	2.0m	2.5m

2. Decide how many students will be "populating" each of the lakes. Use the chart on the next page to assign numbers of students to represent the relative numbers of people living around each lake. Numbers are given for both United States and Canadian residents (U.S./Canada). Remember that Lake Michigan is the only Great Lake that shares no border with Canada.

Materials

- Ball of string.
- Masking tape.
- Area, Population, and Fish Production tables.
- 100 (minimum) wrapped candies or peanuts in shells.
- 5 paper bags.

Earth Systems Understandings

This activity focuses on ESU 1 (beauty and value), 2 (stewardship), 4 (interactions), and 7 (careers and hobbies).

Source

This activity originally came from *Supplemental Curriculum Activities to Accompany Holling's Paddle-to-the-Sea* by Marcia L. Seager, Rosanne W. Fortner, and Timothy A. Taylor.

Note

You may want to invite another class to share in this activity, especially if your class has less than 20 people in it. Larger numbers of participants better illustrate the differing concentrations in population throughout the Great Lakes region.

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Number of People
U.S. / Canada

Total participants	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**
Lake Superior	0/0	0/0	0/0	1/0	1/0	1/0	1/0	1/0
Lake Huron	1/0	1/1	1/1	1/1	1/1	2/1	2/1	2/1
Lake Ontario	1/2	1/3	2/3	2/4	2/4	2/5	3/5	3/6
Lake Erie	4/1	6/1	8/1	8/2	11/2	12/2	13/3	15/3
Lake Michigan	6/0	7/0	9/0	11/0	13/0	15/0	17/0	19/0

3. Divide wrapped candies or peanuts in shells into groups representing the proportional number of fish caught annually in each of the Great Lakes. You will need at least 100 candies or peanuts. One candy or peanut represents approximately 50 tons of fish. Label the five bags with the names of the five lakes and use the table below to put the correct number of "fish" in each bag. (For groups of less than 25 students, you may want to halve these numbers.)

Proportional Number of Fish Caught

Lake Superior	8
Lake Michigan	35
Lake Huron	5
Lake Erie	50
Lake Ontario	2

Procedure

1. Arrange the loops of string that represent the five Great Lakes into the approximate shapes of the Great Lakes. With masking tape, add a dividing line to each lake to show that each lake (except for Lake Michigan) has both a U.S. and Canadian side. Ask the students:
   - Which of the lakes has the largest area? Which has the smallest area?
   - Without using the chart as a reference, where would you guess that most people live?

2. Assign the appropriate numbers of participants to the U.S. and Canadian sides of each of the lakes. (An alternative is to assign participants to each lake without specifying a country. In this case you do not need the border.) Each participant should put one foot on the string "shore" of the lake.
   - Where are people closest together?
   - Did anyone have a hard time finding room to stand?
   - On which lake or lakes do you think the biggest cities are located?
   - Which lakes have the largest and smallest populations?
   - Are more people living near the eastern or the western lakes?
   - Are more people living near the U.S. or the Canadian shores?

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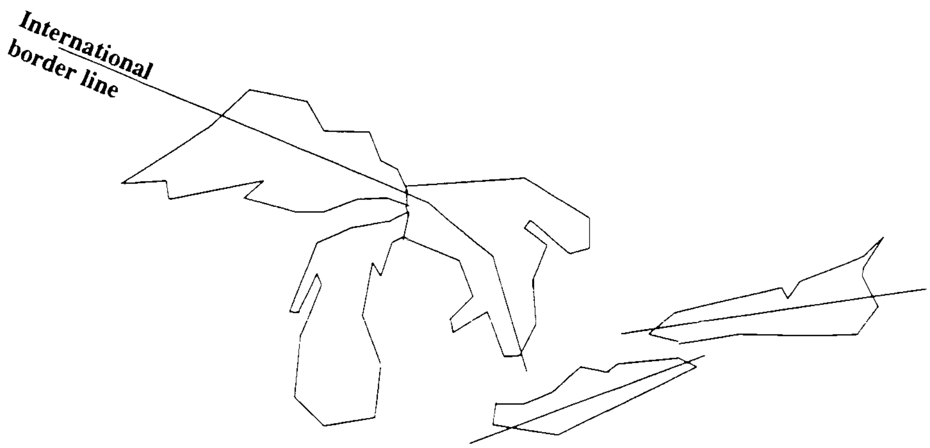

3. Pass the appropriate bag of "fish" around each lake. Each person takes ONE piece of candy or peanut each time the bag is passed to him or her until the bag is empty. (If you have no one assigned to Lake Superior, set aside that bag and do not distribute those "fish" in the other lakes.)

   - Which lake had the most "fish"?
   - In which lake did people catch the most? Why do you think this is so?

4. People create waste when they use resources, and much of that waste is carried by water. Too much waste causes pollution problems. Open and eat your "fish." Put the wrappers or peanut shells on the floor inside the loop of string that is your lake.

   - In which lake is the waste most concentrated (greatest amount, closest together)?
   - Remember that the water from each lake flows into the lake downstream (in this case, to the east) of it. Which lake or lakes do you think might have the worst pollution problems? Why do you think so?

5. Have students use the Great Lakes Atlas and/or the Great Lakes Information Network (GLIN) online to find out more about the uses people make of the Great Lakes, the relative sizes of the lakes, and the human impacts on the region. Start the searches at http://www.great-lakes.net.

6. Clean up and discuss the activity together.

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Discussion Questions

1. What relationships have you seen between population, resources, and waste?
2. What could you have done to make sure ALL participants got an equal number of "fish?" (Sell or trade for other resources or services, for example.)
3. How do you think the amount of pollution in the Great Lakes could be reduced?
4. How could you reduce the amount of waste you produce?

Extensions

Play math games with Great Lakes areas and populations. For example, find out how many times Lake Erie could fit in one Lake Superior, how many people per square meter there are in each lake's watershed, and so on.

Organize a Clean Campaign to learn more about recycling. Find out what lakeshore communities do with wastes from fishing. Use the Internet to find out what the pollution levels are in each of the Great Lakes.

For other activities

This activity was selected from ES-EAGLS *Environmental Issues in the Great Lakes*, 1997. To order the entire volume, contact Ohio Sea Grant Publications, 1541 Research Center, 1314 Kinnear Rd., Columbus, OH 43212. Phone 614/292-8949. 1997 cost $8.

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Who is visiting the shore?

As you have seen in *How big is a crowd?*, much of the environmental quality of the Great Lakes region is related to population density. While your class is at the coast for its Coastweeks program, there are some things you can do to estimate the user population of the area. You can also gather valuable information about how the coast is being used, and estimate its value to people for those uses.

CENSUS. In a census, we simply count all the individuals we see. We define the census area, the time period, and the conditions of the day, because those factors may change how many people we find to count! It is also useful to collect data to divide the population into some obvious classification scheme. For instance, a census of shoreline anglers (people fishing from piers or the shore), of people around or on boats, of general beachgoers (sitting or walking on the sand), of sunset watchers, or other groups that you may note may be done. Remember that your "census" applies only to the day and time of the count, and may not represent all the people and activities at this area.

[Have students think about what other factors might affect the number of people at the coast at a given time.]

Challenge question: What else would you need to know to estimate the total number of users of your area over a year?

SAMPLE. If there are too many people present to actually count, it is more efficient to do a population sample instead. Like the census, a sample can be classified by activities observed. We would need to define the proportion of the total population that we plan to count, how we choose which ones to count, and what that population is doing. For example, we could count every third person doing a certain thing, or count people visible in ten minutes to estimate the population per hour. Depending on where you are, perhaps you could write down the activities of ten people selected at random in each hour of your coast visit.

Challenge question: How could a census done on a Coastweeks day actually be a sample as well?

[Since you are only doing the count on one day, what you are really getting is a representation of how many people come to the coast on a Tuesday (or whatever day) with this kind of weather in this time of year.]

Procedure

1. With your class, determine whether you will take a census or a sample of people at the coast during your visit. Define your boundaries for the population determination and write them in your record sheet. Record the population information you collect.
2. Design a simple questionnaire that you can use with your class to find out about the people at the coast. They came here for their own reasons, not for your survey, so don't plan to ask many questions that keep them from their activities.

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You may want to record things like where they are from, how long they plan to be at the coast, their reason for coming, and how often they come. Observe their relative ages (child, teenager, young adult, etc.) and their gender, as well as how many are in their group.

3. When the class has some data, combine it and discuss:

- What proportion of visitors are "regulars" (coming often)?
- Do more people come in families, alone, or in other groups?
- What seems to be the most valuable aspect of this coastal area for its visitors? Why do they feel this way?
- If the population study was done on a different day of the week, which groups might not be here? Why?
- The class should also make up its own questions based on interest generated by the survey.

4. Make graphs, charts, and maps of your class data in ways that show clearly how the coast is being used and by whom.
5. Look at the general coastal characteristics. Write a short paragraph describing the area's physical attributes.
6. Which of the coastal characteristics seem to be directly related to the activities of the visitors?
7. How is the area managed for people's use? Do visitors seem to be taking care of the area as well?

[Evidence of management might be rake marks in the sand, trash cans present, restrooms or picnic areas built nearby, and such.]

Sharing your data

In small groups, examine different segments of the data your class has collected. Develop a creative way to share the data with others at the Lake Erie Conference or in your school. Make your display or plan your presentation in a way that uses good communication skills and also explains the research method clearly for those who were not involved in it. Be prepared to tell how the data could be used by recreation planners, or natural resource managers, or another group.

Extending your knowledge

You have counted a fraction of the coastal users at the Lake Erie shore. There are other datasets available that will give you information about the Lake Erie coastal population as well. Visit these internet sites to compare your research population with the total shoreline population of Lake Erie.

Great Lakes Atlas: www.epa.gov/glnpo/atlas/intro.html
U.S. Census: www.census.gov

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How does the estuary serve as a nursery?

Among their many functions, wetlands serve as important protective breeding and nursery grounds for fish and other aquatic animals. Aquatic animals such as plankton establish themselves as essential links in the food chain by providing food sources for fish populations. Changes resulting from human activities near the estuary may have severe effects on the aquatic community. Plankton and fish may not be able to adapt to the change, causing a deficiency in food supplies for organisms in the upper food chain.

OBJECTIVES

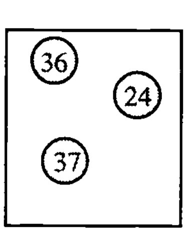
When you have completed this activity, you should be able to:

- Demonstrate the methods used by ecologists to sample populations of plant and animal life in the water.
- Classify the types of organisms that are found as plankton in an estuary.
- Predict the effects of some human and environmental forces on conditions in an estuary.

PROCEDURE

A *sample* is one method that ecologists use to examine a population without observing and counting every organism. A sample can be taken by randomly choosing an area of a certain size and counting all the organisms present. To see how this works, do the following:

1. Take a canning jar ring and drop it anywhere on this page. Count the number of times the letter **E** appears in the circle.
2. Repeat this two more times. Add up your three counts and divide the total by 3. This gives you the average number of **E**s in an area of 43 cm^2 (the area inside the ring).
3. To estimate (make an educated guess about) the total number of **E**s on the page, multiply your average by 9.2, since the page is about 9.2 times as big as the area inside the circle. Round to the nearest whole number.



$$\begin{array}{r} 36 \\ 24 \\ \underline{+37} \\ 97 \end{array}$$

97 / 3 = 32.3
32.3 x 9.2 = 297

Source

OEAGLS EP-16 "The Estuary: A Special Place" by Rosanne W. Fortner and Ron Mischler.

Earth System Understandings

This activity focuses on ESU 3, science methods and technology, 4, interaction, and 5, change through time. See the introduction to the activity set.

Materials

- "Plankton samples" in Figures 2 and 3.
- Ring from a canning jar (wide mouth, having an inside diameter of 7.4 cm).
- Pencil.

Teacher's Note

Have the students practice the technique and calculations for the **E** "population" on one or two printed pages before going on to the plankton pages.

If for some reason you wish to use the regular-mouth jar rings, having the i.d. of 5.7 cm, use 25.5 cm^2 for the area in Step 2, and use 15.4 for the multiplication factor in Step 3.

In sampling for Figures 2 and 3, students will often have organisms that are only partly visible in the ring. Follow the general rule that if one half of the organism or more is visible, the students should count that as one whole organism. For algae clumps, it is probably most accurate to count every strand of algae as a different organism, rather than counting clumps or clusters.

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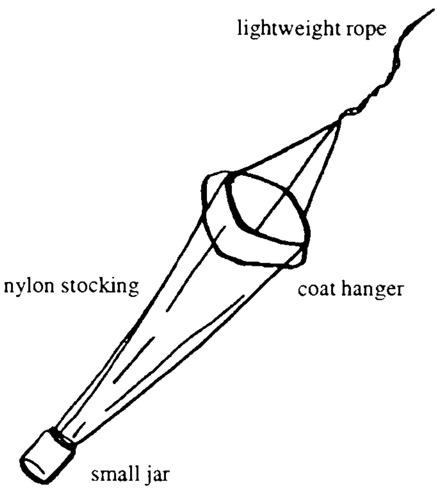
Figure 1. Student-made Plankton Net.



Hint

In the table on the worksheet, the first type of algae listed is Diatoms. When recording your sample, count both kinds shown, and list them together as Diatoms. Do the same for the green and blue–green algae. The number you write will be a total for both species in each category. In the case of the zooplankton, only one species of each of the different groups is shown.

Answers to Procedure

For most of the following, results would probably be more accurate if the entire class would pool its information.

A. 1. Spring
2. Summer
3. Spring
4. Summer
5. Spring
6. Spring
7. Summer

Now let's pretend that a jar of water has been collected from the Old Woman Creek estuary. It was collected in a special way. A plankton net (Figure 1: student–made plankton net) was towed behind a boat for about five minutes. The net had a jar at the end that caught all the tiny organisms in the water, while the water escaped through holes in the net.

The jar of water has thousands of organisms in it. You can tell they are there because they keep the water churned up in the jar, but you can't see them well enough to tell what they are. You need a microscope.

Figures 2 and 3 show some of the animals you might see through the microscope. Figure 2 is from a plankton sample collected in May, and Figure 3 is from an August sample. Look at the organisms shown and compare them to the pictures in the chart on your worksheet. Be sure you tell which are algae, zooplankton, and fish larvae.

4. Repeat the sampling method you used for the letter e but this time sample the organisms in Figures 2 and 3. It is best if you actually trace your sampling circles on Figures 2 and 3. This will make it easier for you to record on the chart and still not disturb your sample (move the ring). Also, you can come back to your samples and recheck them as the need arises. Record your results on the worksheet.

Figures 2 and 3 are based on actual plankton samples collected along the Lake Erie shore. Both the numbers and types of organisms are therefore fairly accurate examples of what may be found in the Old Woman Creek area.

Hopefully, those of you who said, "But why not just count all the **E**s?" on the **E** sampling page can see better why scientists frequently resort to sampling techniques. (Imagine a scientist trying to count all the individual organisms in the estuary!)

5. Answer the following questions based on the samples you "collected."

A. Which season had these characteristics?
1. The greatest number of diatoms
2. The greatest number of blue-green algae
3. The greatest number of zooplankton
4. The warmest water
5. The most gizzard shad larvae
6. The most yellow perch larvae
7. The most sheepshead larvae

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B. Young perch eat a lot of algae. Which season would have the most food for baby perch? In which season are the perch spawned (eggs deposited)?

C. Do all the types of fish in the sample spawn at the same time? How can you tell?

D. You have noted that the water is warmer in which sample? Water temperature is an important factor in determining when fish spawn. Which species appear to require warmer water for spawning?

E. What would be the advantage of having different fish spawn at different times?

F. Fish may enter an estuary to spawn. Based on what you learned in the previous estuary activity, why else might fish come into the estuary?

G. You now have information about the microscopic organisms in an estuary. In "What is the role of plants in an estuary?" you investigated the activities of some of the macroscopic (visible to the unaided eye) organisms in an estuary. Using what you have learned, predict the effect of the following events on the plants and animals of the estuary.

1. Heavy spring rains raise the level of the creek 1 foot higher than it is now. The water also flows very fast.
2. Hot water is dumped into the estuary by a utility company.

Answers to Procedure

B. Perch spawn in spring (March-May). There is more food for them in summer, however. Note that they have yolk sacs in the May plankton sample. The larvae use the yolk as food, then begin to feed on algae.

C. No. There are no bass or sheepshead in the May sample. They appear as yolk-sac larvae in the August sample.

D. Summer water is warmer. Sheepshead and white bass appear to require warmer water for spawning.

E. Spawning times could be related to the availability of food for the larvae. There may also be temperature tolerances of the fish to be considered, and some fish are sensitive to overcrowding. Another reason could be to keep species from interbreeding. Discuss all possibilities that students suggest.

F. Fish might also enter the estuary to eat or to find shelter among the water plants.

G1. Rooted plants may be washed out or completely submerged which would kill plants that are ordinarily emergent. The mud of the bottom could be washed out, preventing plants from becoming reestablished. Plankton would be swept out into the open water of the lake. Adult fish might find more spawning sites in the submerged plants, but there is a greater chance of eggs and larvae washing away into the lake where they could be killed by temperature changes or eaten by other fish. Muddy water would reduce the ability of sight-feeding fish to find food. If larvae remained, their food supply would probably be reduced because of plankton loss. Shore birds would probably have more trouble catching small fish, and the nest sites for the birds could be destroyed.

G2. Plants could be killed. Plant plankton would probably increase in number up to a certain water temperature. Zooplankton would probably be killed. Fish that depend on warmer water temperatures to determine their spawning time

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might spawn earlier than usual. If the temperature got too high, some fish would not enter the estuary at all. Fish larvae might have more algae to eat, but excess heat could kill both eggs and larvae. The food supply would be affected.

G3. Removal of bottom sediments would cause destruction of the water plants rooted there. Fish, shore birds and other animals that depended on the plants for breeding areas, food or shelter would no longer enter the estuary. Plankton would be washed out into the lake. (No water plants would be available to hold them back.)

G4. Nobody wants a marsh as a back yard. We can assume that the water edges are bordered by seawalls or sand beaches in front of the homes. The character of the estuary would be completely changed. Few rooted plants could survive and there would be few plankton. Adult fish would move further inland to spawn, or spawning may be prevented, thus no eggs would be produced to continue the species in that area. Food supply would decrease, so animals would need to find other feeding grounds. Few plants would remain so that there would be no nest sites. Students will probably have interesting ideas on what changes would be involved. All possibilities should be discussed.

For additional activities:

This activity was selected from ES-EAGLS: *Life in the Great Lakes*, 1997. To order the entire volume of activities, contact Ohio Sea Grant Publications, 1541 Research Center, 1314 Kinnear Rd., Columbus, OH 43212. Phone 614/292-8949. 1997 price $8.

3. The estuary is dredged out so that boats can go up the creek. The mouth of the estuary is deepened and probably protected by a sea wall. A portion to be used as a marina is deepened as well to a depth of 2 to 3 meters.

4. The estuary is filled in on the sides so that new homes can be built near the water.

Review Questions

1. Explain what is meant by population sampling.

2. Describe a sampling method for a microscopic community.

3. What types of organisms might be found in an estuary plankton sample? Do you think having a diversity of organisms in an estuary is important? Why or why not?

4. Explain how a temperature increase could affect the number of plankton in a lake. Select another human induced change discussed in the activity and explain its potential effect on the microscopic community. How will these changes affect fish and other animal species in the food chain?

5. Why are estuaries considered to be "endangered environments?"

Extension

Have the students create their own "plankton sample." Place a handful of straw in a container of water in the sun. Using a microscope, examine changes in the number and types of organisms in the water over several days.

References

Eisenhower National Clearinghouse has online information about wetland resources (http://www.enc.org). Toll-free number: 1-800-621-5785.

The E.P.A. has educational resources available for the classroom. Contact the Wetlands Information Hotline 1-800-832-7828 for printed material, posters, and other resources.

Some state agencies may provide field trips for students. They also could have manuals available regarding wetlands in your area. Contact your state's natural resource agencies for more information.

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Figure 2. Estuary Plankton Sample, May (water temperature 13°C).

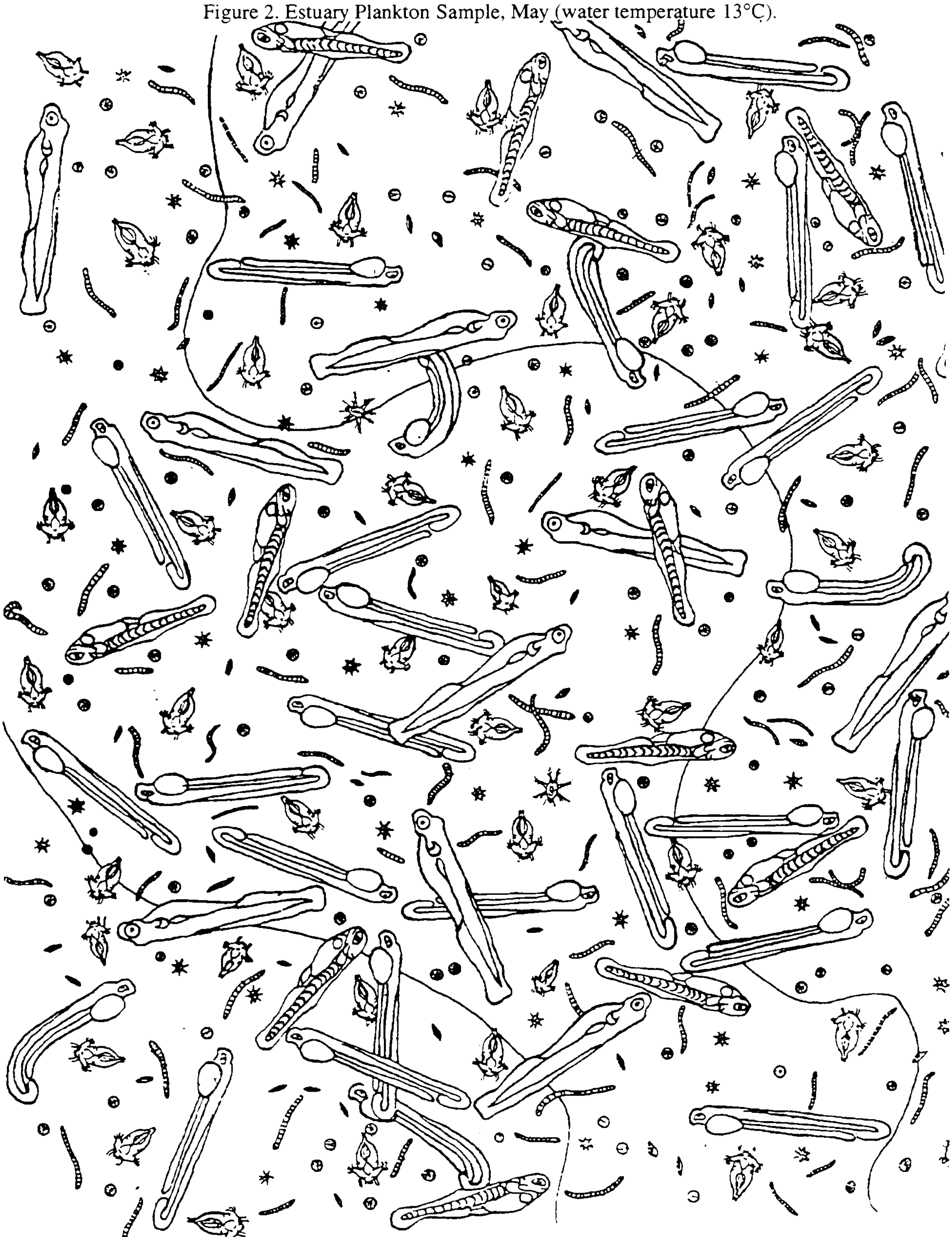

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Figure 3. Estuary Plankton Sample, August (water temperature 21°C).

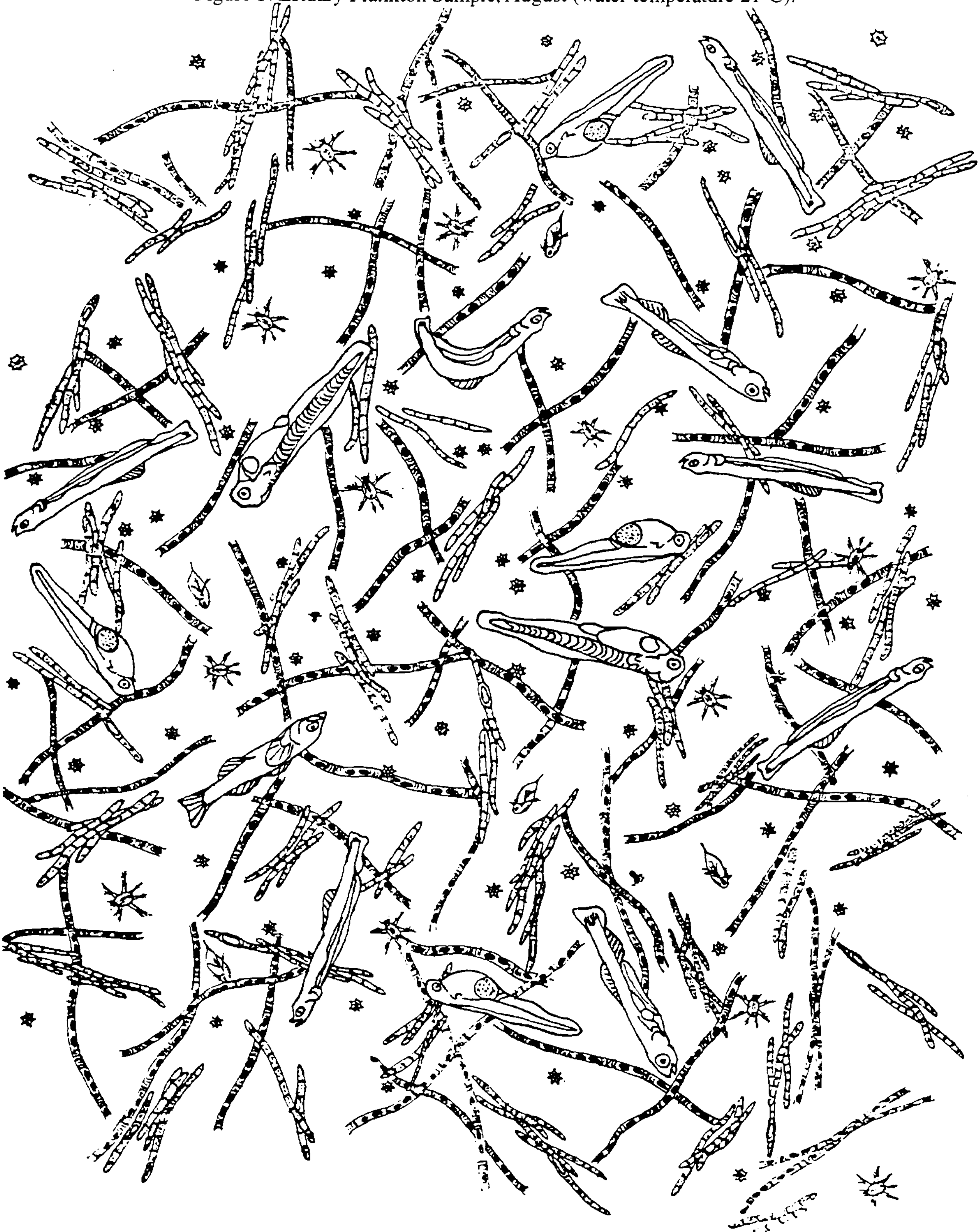

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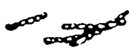
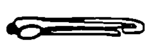
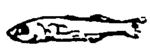
Figure 4. Worksheet for Estuary Plankton Sample.

PLANKTON SAMPLE

	May Sample (Fig. 6)					Aug. Sample (Fig. 7)				
Organism	1	2	3	Ave.	Total Pop	1	2	3	Ave.	Total Pop.
Algae:										
Diatoms 										
Green 										
Bluė-green 										
Zooplankton:										
Cladocerans 										
Copepods 										
Protozoans 										
Rotifers 										
Fish Larvae:										
Yellow Perch  Yolk-sac larva										
 Regular larva										
Gizzard Shad  Yolk-sac larva										
 Regular larva										
White Bass  Yolk-sac larva										
 Regular larva										
Sheepshead (freshwater drum)  Yolk-sac larva										
 Regular larva										
Emerald Shiner  Yolk-sac larva										
 Regular larva										

*Yolk–sac larvae have just emerged from eggs. A yolk-sac larva is younger than a regular larva.

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Where go the boats?

When the United States of America proclaimed itself in 1776 to be an independent nation, all of its cities were busy sea ports. The young nation clung to the ocean, finding there a source of food, an avenue for trade, and a barrier against the powerful nations of Europe. Two hundred years later the population centers of America are still linked to bodies of water. In fact, more than three-fourths of the U.S. population can be found in those states which border the Great Lakes and the ocean.

—*G. Mangone, Americans and the World of Water*

Our waterways connect us with the rest of the world. The Great Lakes have 22 international deep-water ports joined to the world ocean by a series of locks and channels called the St. Lawrence Seaway. The system creates a waterway 2,340 miles (3,774 km) long, through which goods may be shipped to and from the heart of North America.

"Green leaves a-floating,
Castles on the foam,
Boats of mine a-boating,
Where will all come home?"

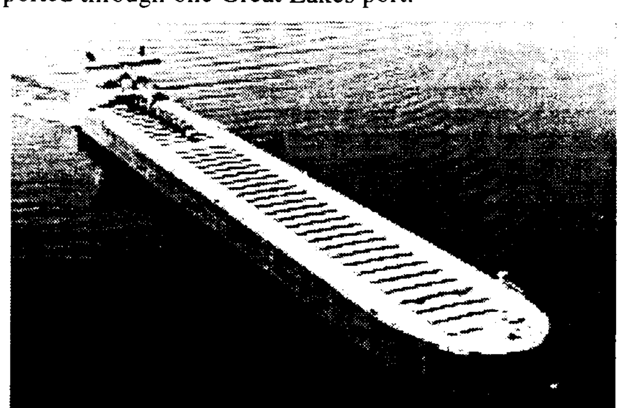
-Robert Louis Stevenson, "Where Go the Boats?"

Ships flying the flags of over 50 nations regularly use the trade routes of the Great Lakes. They make these waterways the world's most important inland water transportation system by connecting interior America with the markets of the world.

OBJECTIVES

When you have completed this activity, you should be able to:

- Discuss the importance of the Great Lakes in world shipping.
- Explain what is meant by the registry flags of commercial ships.
- Summarize the main types of products imported and exported through one Great Lakes port.



Source

Activity A, OEAGLS EP-20. *Shipping: The World Connection*, by Rosanne W. Fortner, The Ohio State University, and Ray Pauken, Columbus City Schools.

Earth Systems Understandings

This activity focuses on ESU 3, science processes and data, and 4, interactions. ESU 7, careers, is applied in Extensions.

Materials

- Reference map of the world.
- Two colored pencils per team.
- Outline map of the world (Map pg. 24).
- Cargo information from the Port of Toledo for a portion of one year (Table 1).
- Two colored pencils per map.
- World map (political) for reference.

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NOTE: Information to teachers is enclosed in boxes in this guide.

Procedure

A. Find the Great Lakes on your world map. Label the Port of Toledo (on Lake Erie) with an X.

B. Look at the International Shipping (Table 1, pages 29-31) for the Port of Toledo. Notice the columns labeled "From" and "To." These tell you where a ship is coming from (its last port) and where it is going next. For some ships, these ports were not known.

C. Now look at the column labeled "Flag." This tells the country in which a ship is registered. The ship flies that country's flag.

D. Use one colored pencil to shade in all those countries listed under either "To" or "From" for the ships given. Use a reference map to find out where these countries are.

E. With a second colored pencil, make slash lines through any country listed in the "Flag" column.

Answer the following questions based on the table and your completed map.

1. The shipping season opens when shipping lanes and locks are free of ice. When did the shipping season open in this example year?
2. When did the season close? Why?
3. About how much of the world was affected by trade with the Port of Toledo in this example year?
4. Which two flags are most frequently flown by international trade ships using the Port of Toledo?
5. Did ships flying these flags actually sail to or from those countries?
6. Are these countries the leaders in world trade? (Consult the World Almanac for recent years.) Discuss this answer with the rest of the class.
7. Classify Toledo's outgoing products (exports) as being foods, manufactured goods, timber, or miscellaneous. For each continent, tally the number of ships carrying each type of product out of Toledo and record the numbers in the chart provided.

Answers

A-E. Students use the International Shipping tables to construct a two-colored map, or one map in one color overlaid by a transparency with the other color. To find all the countries needed, they should have access to a standard world map or large globe. For younger students, you may need to mark the tables to indicate the continent for each country. Also, small reference maps sometimes do not show Cyprus and Malta. Both are islands in the Mediterranean Sea.

1. The shipping season opened in April.
2. The season closed in December because of ice in the shipping lanes and locks.
3. Two-thirds to three-fourths of the world was affected by trade through Toledo in this example.
4. Flags of Greece and Yugoslovia.
5. Ships under those flags did not come or go from those countries.
6. The countries are not leaders in world trade. This discussion calls for speculation by the students. Accept all reasonable answers and discuss them. According to Robin Burton ("Flags of Convenience," *Sea Frontiers* 21(5): 294-302), a person who owns a merchant ship and registers it in another country to save money on taxes and wages is using that country's flag for convenience. In the recent past (up until about 1975), many of these convenience countries did not require inspection of vessels or training credentials for crew members. It was not uncommon for safety conditions to be neglected, ships to fall into disrepair, and crew members to be speaking five different languages. Now, international regulations are tighter, and many ships under flags of convenience are there for fuel savings and income tax relief only, with safety and training standards checked regularly.

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8. Classify imports as being foods, manufactured goods, raw materials for industry, and miscellaneous. For each continent, tally the number of ships carrying each type of product into Toledo, and record the numbers in the chart.

9. With which continent does the Port of Toledo carry on the most trade?

10. What is the main export to that continent?

11. What is the main import from that continent?

12. Based on the imports chart, what is one of the main industries in Europe?

13. Based on the exports chart, what U.S. products do the developing nations of Africa need most?

14. The ships on the Port listing carry different amounts of the cargoes listed. If you consider the number of ships only, which is greater from the Port of Toledo, imports or exports?

9. Europe provides most of the trade through Toledo.

10. The main export to Europe is food.

11. The main import is raw materials for industry.

12. From the list of raw materials on pages 5-7 of the Student Guide, mining (to get the raw materials) is shown to be a major European industry.

13. Africa gets food through Toledo.

14. Exports exceeded imports in this example year.

TOLEDO EXPORTS

Product	Number of Ships to: Europe	Asia	Africa	South/Central America
Food				
Raw Materials for Industry				
Manufactured Goods				
Miscellaneous				

TOLEDO IMPORTS

Product	Number of Ships from: Europe	Asia	Africa	South/Central America
Food				
Raw Materials for Industry				
Manufactured Goods				
Miscellaneous				

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Toledo is only one of 22 deep water ports on the Great Lakes. Using the information from this activity, based on part of one year's shipping from one port, you can probably begin to see how important the Great Lakes are in world trade.

15. Railroads and trucks would have to transport goods if the St. Lawrence Seaway were not available. These are less energy-efficient and more expensive forms of transport. See ES-EAGLS activities in this set: What is the most economical . . . and which transportaion method uses the least energy?

15. If ocean going ships could not reach Toledo and other Great Lakes ports, how would U.S. products have to be transported?

1977	Total Seaway Tonnage	63.4 Million Tons
1978	Total Seaway Tonnage	62.8 Million Tons
	Total bulk shipments (grain and iron ore)	57.7 Million Tons
	Total tonnage handled at Duluth-Superior alone	45.9 Million Tons
	Number of ocean-going ships in Soo Locks	378
	Number of countries represented	32

1995 ANNUAL REPORT of the Lake Carriers Association

The vast majority of these cargos were carried by U.S. and Canadian lakers. Third-flag vessels participate primarily in the export grain trade.

GREAT LAKES DRY- AND LIQUID-BULK COMMERCE: 1995-1994
(net tons)

	1995	1994
IRON ORE		
From Lake Superior	50.733.237	51.100.995
From Lake Michigan	8.156.539	7.382,654
From Eastern Canada	11.703.550	11.633.096
Total Iron Ore	**70,593,326**	**70,116,745**
COAL		
From Lake Superior	15.270.969	15.823.338
From Lake Michigan	1.131.491	796.124
From Lake Erie	16.541.326	18.382.318
Total Coal	**32,943,786**	**35,001,780**
LIMESTONE, GYPSUM		
From U.S. Ports	30.947.398	29.675.439
From Canadian Ports	3.617.310	3.162.876
Total Stone	**34,564,708**	**32,838,315**
SALT	**6,717,037**	**7,510,169**
CEMENT	**4,617.555**	**4,652.255**
POTASH	**657,256**	**666,918**
Total Dry-Bulk Cargo	**150,093,668**	**150,786,182**
LIQUID BULK	**4,730,467**	**4,628,346**
Total All Commodities	**154,824,135**	**155,414,528**
GRAIN	**18,800,637**	**18,107,236**
Total Including Grain	**173,624,772**	**173,521,764**

To convert iron ore to gross tons, multiply by .89286

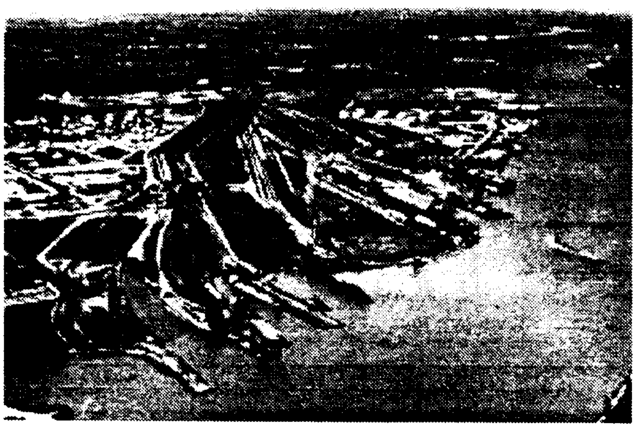

Photo of the Port of Toledo

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Table 1. PORT OF TOLEDO
INTERNATIONAL SHIPPING
(a portion of one year)

Vessel Name	Flag	Cargo In	From	Cargo Out	To
April					
Hermine	France	—	—	Soybeans	Spain
Arkandros	Liberia	—	—	Jeeps	Morocco
Makarska	Yugoslavia	Wine	Italy	Timber	Italy
Paula L. Russ	Germany	Machinery	Germany	Timber	Germany
Baltic Skou	Denmark	Chrome Ore	Norway	—	—
Redsea Venture	Liberia	Liquid Fertilizer	Netherlands	—	—
Span Terza	Italy	Foundry Coke	Belgium	—	—
Eglantine	France	Steel	France	—	—
Sealord	Panama	—	—	Wheat	Morocco
Parthenon	Greece	—	—	Corn	England
May					
Comas	Singapore	—	—	Soybeans	Russia
Thurdrecht	Netherlands	—	—	Corn	Scotland
Hilary B	Singapore	Raw Sugar	Panama	—	—
Tozui Maru	Japan	—	—	Soybeans	Japan
Kapitan Panfilov	Russia	Aluminum	Russia	—	—
Zabrze	Poland	—	Europe	Timber	Belgium
Milanos	Spain	Steel	Italy	—	—
Jadro	Yugoslavia	Miscellanous	Italy	—	—
Valya Kotik	Russia	—	Europe	Timber	Netherlands
Auctoritas	Italy	—	—	Soybeans	Italy
June					
Peter L	Greece	Raw Sugar	Honduras	Wheat	Algeria
Victoria Faith	England	—	—	Corn	Morocco
Lake Aniara	Norway	Liquid Fertilizer	Netherlands	—	—
Arctic	Canada	—	—	Corn	Belgium
Rubens	England	Foundry Coke	Germany	Corn	W. Germany
Delchim Cevennes	France	—	—	Petroleum Prod.	France
Federal Calumet	Liberia	Furnace Coke	Germany	Corn	Netherlands
Lynton Grange	England	Steel	England	—	—
George L	Greece	Furnace Coke	Belgium	Corn	Netherlands
Union Pride	Greece	Miscellanous	Canada	Autos	Chile

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Vessel Name	Flag	Cargo In	From	Cargo Out	To
July					
Shura Kober	Russia	—	Europe	Cob Pellets	England
Baam	Netherlands	Machinery	Germany	Machinery	Netherlands
Hosei Maru	Japan	—	—	Soybeans	Japan
Teesta	India	Steel	India	Wheat	Algeria
Zabat-Dos	Spain	Zinc	Spain	Corn	Spain
Marcos Souza Dantos	Brazil	—	Brazil	Machinery	Brazil
Koper	Yugoslavia	—	—	Wheat	Nigeria
Lake Katya	Liberia	Liquid Fertilizer	Netherlands	—	—
Sugar Crystal	England	Steel	England	—	—
Satya Kamal	India	Chrome Ore	Norway	—	—
August					
C. Mehmet	Turkey	Steel	France	—	—
Carchester	England	—	England	Corn	England
Kiyo	Liberia	—	—	Soybeans	Japan
Katherine	Greece	—	—	Corn	Scotland
Prvi Februar	Yugoslavia	Furnace Coke	Belgium	—	—
Blumenthal	Germany	—	Ecuador	Miscellanous	Venezuela
C. Tahsin	Turkey	Steel	Belgium	—	—
Shirley Lykes	America	—	Italy	Machinery	Egypt
Tilly Russ	Germany	Miscellanous	Europe	Miscellanous	Europe
Dubrovnik	Yugoslavia	—	—	Corn	Scotland
September					
Puhos	Finland	Urea	E. Germany	—	Duluth, MN
Hand Fortune	Panama	—	—	Corn	England
Zambrow	Poland	—	Belgium	Timber	Belgium
Adriatik	Yugoslavia	Furnace Coke	Belgium	Soybeans	Belgium
Torm Kristina	Denmark	—	—	Soybeans	Netherlands W. Germany
Ektor	Greece	Steel	France	—	—
Federal Clyde	England	—	—	Soybeans	W. Germany
Arkandros	Greece	—	—	Corn	Malta
Split	Yugoslavia	Miscellanous	Greece	Miscellanous	Yugoslavia
Meltemi II	Greece	—	—	Corn	England
October					
Ever Honor	Cyprus	—	—	Soybeans	Netherlands
Totai Maru	Japan	—	—	Soybeans	Japan
Harmonious	Panama	Chrome Ore	Norway	—	—

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Vessel Name	Flag	Cargo In	From	Cargo Out	To
Jean Lykes	America	—	Italy	Machinery	Egypt
Murray	Liberia	—	—	Soybeans	Japan
Zamosc	Poland	Zinc and Machinery	Belgium	Timber	Netherlands
Zinnia	England	—	—	Soybeans	Germany
Lena	Greece	—	—	Corn	Scotland
Providence	Panama	Furnace Coke	Germany	—	—
Caspiana	Greece	—	—	Corn	Italy
November					
Boujniba	France	—	—	Corn	E. Germany
Atlantic Helmsman	Greece	Furnace Coke	Germany	Soybeans	Spain
Paul L. Russ	Germany	Miscellanous	Germany	Timber	Germany
Ondine	France	Steel	France	Wheat	China
Dunav	Yugoslavia	—	—	Soybeans	W. Germany
Kara	Finland	Metals	Finland	—	—
Efploia	Greece	Furnace Coke	Germany	—	—
Federal Seaway	Greece	—	—	Soybeans	Indonesia
Olympic Hope	Greece	Furnace Coke	Germany	Corn	Germany
Ashley Lykes	America	—	Italy	Machinery	Italy
December					
Thorswave	Norway	—	—	Timber	Germany
Federal Rhine	Liberia	—	—	Corn	Germany
Tokei Maru	Japan	—	—	Corn	England

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Review Questions

1. List the continents that send goods to or receive products from a typical Great Lakes port.

2. What is the main type of product exported through the Port of Toledo? through the Lake Carriers in general?

3. What is the main type of product imported?

4. What determines the length of the Great Lakes shipping season?

5. Why might a company register its ships in a foreign country if the ships do not trade with that country?

Extension

Compare the shipping season and types of cargo exchanged at a port near your location. See if you can account for the differences and similarities based on climate, local economics, transportation available, and other factors.

For additional shipping activities

This activity was selected from ES-EAGLS Great Lakes Shipping. 1997. To order the complete volume, contact Ohio Sea Grant Publications, 1541 Research Center, 1314 Kinnear Rd., Columbus, OH 43212. Phone 614/292-8949. 1997 cost $8.

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Great Lakes Shipping Today (Lake Carriers Association)
http://little.nhlink.net/wgm/lca/today.html

Great Lakes shipping schedules
http://www.acs.oakland.edu/~ncschult/boatnerd.html

Great Lakes Bookshelf (Harbor House Publishers)
http://www.harborhouse.com/bookshel.htm

Great Lakes buoy data
http://www.ems.psu.edu/wx/regions/greatlakes.html

Lake Carriers Association Web page
http://www.en.com/lcaships/

Maps
http://www.great-lakes.net:2200/ecosystem/tools/maps.html

U.S. Army Corps of Engineers
http://sparky.nce.usace.army.mil

Address for other information:
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(216)621-1107

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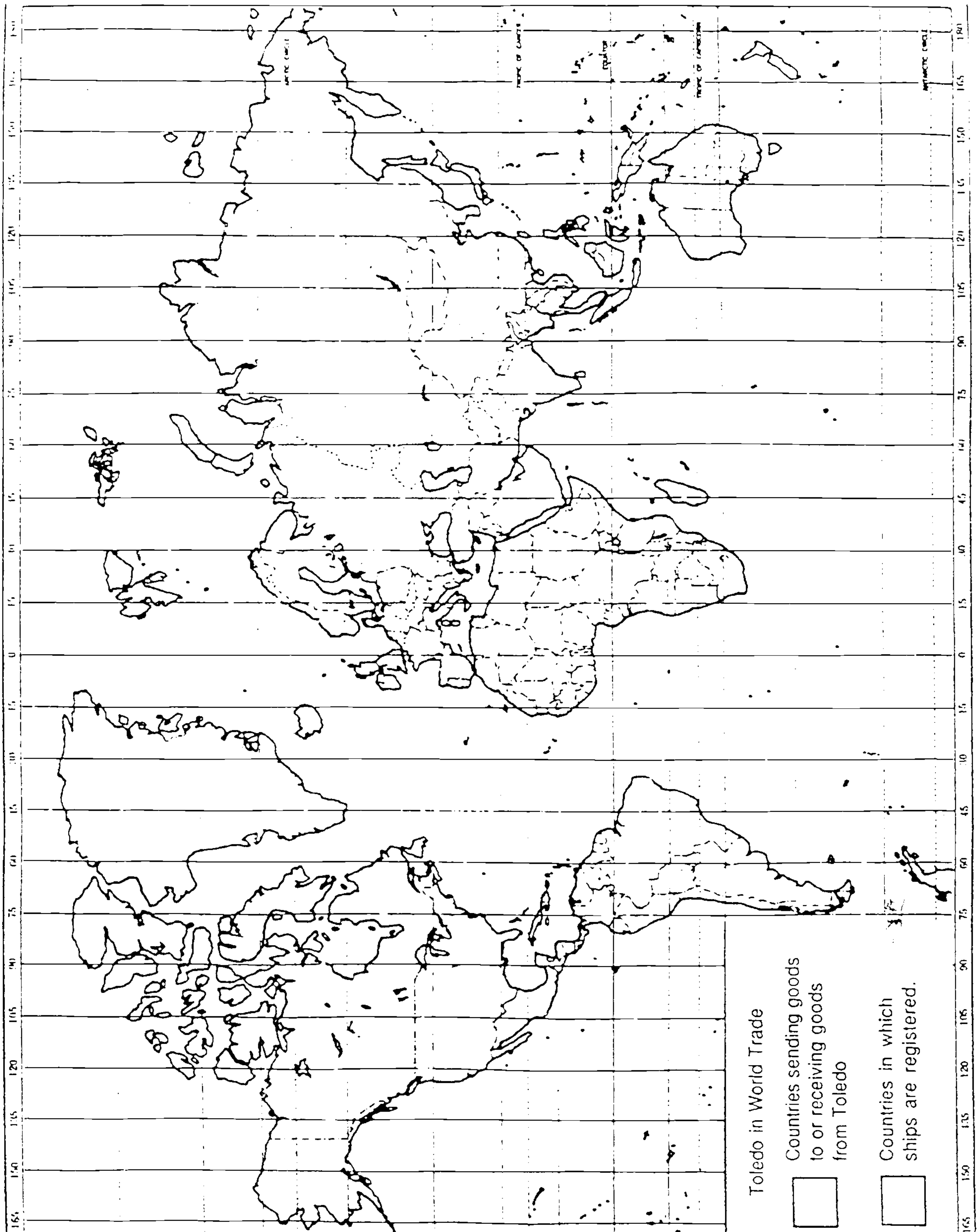

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What kinds of boats come to this area of the coast?

Any boat has the potential to contribute to water pollution, and the data available from the Center for Marine Conservation reflects these impacts. Look at the data in Table 5. It is not often possible to tell where marine debris comes from, but wastes from boats and from fishing operations can usually be sorted out from those wastes that come from the land instead. In 1995, the Great Lakes states reported that about 0.5% of their debris came from recreational fishing and boating, and 1.26% came from commercial fishing wastes. For Ohio alone, those amounts are 0.63% and 2.38% of the debris collected. Monofilament line and plastic netting are the most prevalent forms of these wastes and also the ones that are most dangerous for entangling wildlife.

Most of the boats you will see on a visit to Lake Erie will be pleasure boats taking people out to fish or to visit the islands or just to have a relaxing time on the water. Perhaps your class will encounter enough boats on the Coastweeks visit that you can count them and make maps to determine where they originated. Boaters are often pleased to tell you about their craft and where it has been!

PROCEDURE

With your class, collect available data in small groups, and then share your data with the class to get a view of the boating public in your area.

Group 1. Cargo ships.
Visit the internet sites *http://little.nhlink.net/wgm/lca/today.html*, *http://www.acs.oakland.edu/~ncschult/boatnerd.html* or contact the nearest Lake Erie port and get information on the ships that visited the port in the most recent month of record. Where did the boats come from and where were they bound? What were they carrying? What flag was being flown (country of registration)? Ask the port authority what the ships do to unload waste while they are in port, and how they avoid polluting the water of the port when they are operating there. If the port is called by phone, this should be done by only one member of the group. Make sure your questions are well thought out, and that you are courteous on the phone. You might offer to fax a list of questions if someone you contact is willing to answer them for the class.

Group 2. Charter fishing boats and "head boats"
These are boats that people choose when they can pay to go out in the lake to fish. Depending on where you go along Lake Erie, there may or may not be many of these vessels. The most biologically productive parts of the lake are in the Western Basin, from the islands westward, so that area has the largest number of charters. Other ports with public marinas may also have charters. Check the yellow pages and have each member of the group call at least one charter company. Explain that you are a student

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seeking information for an assignment. Get the rates for fishing, the kinds of fish they specialize in, and how many people can fish from the boat at one time. Finally, ask how fish waste and human debris (trash from lunches, flushes from the head, etc) are handled aboard the boats. Be sure to thank the person you have contacted.

Group 3. Recreational boaters – motorboats, and
Group 4. Recreational boaters – sailboats

These groups may be found at a local marina, and the marina operator should be contacted for permission to go out on the docks to visit them. Some docks do not allow visitors. If you are able to speak to the boaters, ask them questions similar to those in the population survey on page 1-2. Ask how the boaters deal with wastes from the boats and people. If you can reach the boats but not the boaters, catalog the boat names and the registration cities listed on the hulls. Some will not have the cities but will have a state abbreviation in the license number on the hull. Compare the names of motorboats with those of sailboats! If they are different, explain why you think they are. Make a map of where the boats come from.

[Coastweeks data from the Center for Marine Conservation include information about the debris in underwater clean-ups at Put-in-Bay. Check the internet site or contact CMC by e-mail: cleanup%hampton@cenmarine.com]

Group 5. Passenger and car ferries, and "island hopper"

At the present time, ferries operate in the Western Basin only, but island hopper boats and some cruise lines will visit Cleveland and other cities as well. If possible, contact the companies that operate the boats and get information on how many people and cars are carried in one "average" month. If you observe some of the boats, collect your own data on that question. Examine the water near the docks where you find these boats. What evidence is there that large numbers of people or large boats come to these areas? What are the companies doing to control waste discharge into the water?

Sharing your data

Combine your data across all the class groups. Make a list of what is being done to control waste from boats. Which types of boats need a greater amount of control? Who monitors the boats to see that they are protecting water quality? What can you do as a concerned citizen if you find boat waste in a beach cleanup? Who should know about the wastes from boats? Develop a communication tool to make your information known to people who will do something about any problems you have detected.

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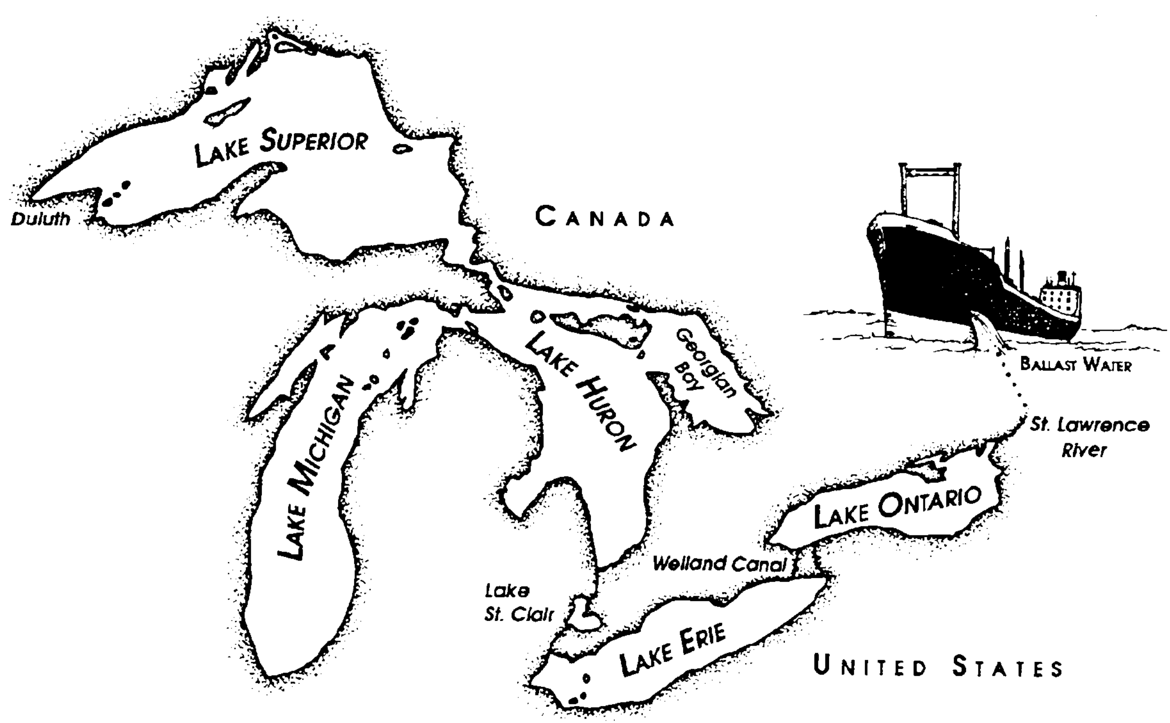
What do scientists know about invader species of the Great Lakes?

Since the early 1800s, over 140 species of aquatic plants, algae, fish, worms, mollusks, and other organisms have invaded the Great Lakes. Likewise, some North American species such as the green sunfish (*Lepomis cyanellus Rafinesque*) have migrated eastward and have become pests in Europe. Biologists worry about these intrusions, because each new species in the Great Lakes alters the region's ecosystem. Any environment has a fixed amount of energy that must be divided among all the species present. When a foreign (exotic) species invades an ecosystem, it often has no enemies. This allows an invader to increase rapidly, displacing native organisms by filling their niches. This change allows the once biodiversified region to lose some of its genetic diversity.

It is estimated that about 15 percent of the 175 species of fish in the Great Lakes are nonnative species that were introduced accidentally or intentionally. Eighty-six invader species are plants, although plants have received less attention as invaders. How these invaders get into the region is variable, but many have been shipped in unintentionally.

When ships are not loaded with cargo, they take on ballast to balance and stabilize them as they travel. The use of water as a ballast material has replaced the use of sand and stones. Ballast tanks are filled with water from the harbor where ships are loaded, and then dumped, along with any aquatic organisms present, when ships reach their destination. It is estimated that in the history of the Great Lakes, 34 percent of the invader species entered in solid ballast and 56 percent through ballast water. As shipping times between continents becomes shorter, the threat of introducing live exotics becomes greater.

The United States and Canada have requested that all ships entering the Great Lakes discharge their water ballast while still in the ocean, replacing it with salt water to reduce the introduction of new exotic species. About 90 percent of the ships currently comply with the request.



Source

Modified from "What do scientists know about Great Lakes invader species and the effects of global change on them?" In *Great Lakes Instructional Material for the Changing Earth System (GLIMCES)* by Rosanne W. Fortner, Heidi Miller, and Amy Sheaffer. Ohio Sea Grant Education Program, The Ohio State University.

Earth System Understandings

This activity focuses on ESU 3, 4, and 5. In addition, Extensions address ESU 1, 2, 6, and 7. Refer to the Framework for ESE for a full description of each understanding.

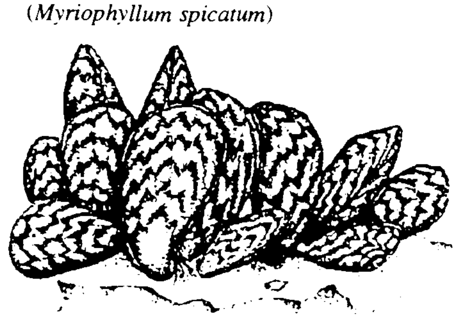
Materials

For each group of 3–4 students:

- Copies of the included information cards. Each of the three card categories (invader picture, introduction, ecosystem impact) should be copied onto a different color card stock paper. [24 cards per group]
- Answer sheet.

Invader Species in this Activity

Zebra Mussel
(*Dreissena polymorpha*)
Sea Lamprey
(*Petromyzon marinus*)
Spiny Water Flea
(*Bythotrephes cederstroemi*)
River Ruffe
(*Gymnocephalus cernuus*)
Alewife
(*Alosa pseudoharengus*)
White Perch
(*Morone americana*)
Purple Loosestrife
(*Lythrum salicaria*)
Eurasian Watermilfoil
(*Myriophyllum spicatum*)



Objectives

At the completion of this activity you should be able to:

- Name and visually recognize some invader (*nonindigenous*) species of the Great Lakes.
- Locate on a world map the origins of the Great Lakes invader species.
- Explain the ways in which invader species are introduced into the Great Lakes.
- Analyze the impacts of invader species on the Great Lakes ecosystem.

Procedure

1. Work in groups of three to four people each, with a complete set of 24 shuffled cards. (If there are eight groups, each group will be able to take a separate invader to report on at the conclusion of the activity.)
2. Beginning with the picture of the invader, match the cards to determine which introduction and ecosystem impact card goes with each invader. For each picture, there should be one matching card of each other color.
3. When group members agree that they have matched the cards to the best of their ability, you may check your answers on the answer sheets.
4. Each group selects an invader to present to the class; construct a poster on the invader, develop a fact sheet, or create a skit to introduce your invader. The impact of the invader on human affairs should be included.
5. Consult the Internet for up-to-date information. Begin with sites for the Great Lakes Panel on Aquatic Nuisance Species, for example http://www.glc.org/projects/ans/anspanel.html, and find others you find interesting. Other examples include:

   http://www.great-lakes.net/envt/exotic/exotic.html – Exotic Species in the Great Lakes region.

   http://www.nfrcg.gov/nas/nas.htm – National Biological Service's, Nonindigenous Aquatic Species (NAS) Information Resource.

   http://patton.nfrcg.gov:80/zebra.mussel – zebra mussel information resources, including U.S. distribution maps by year.

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REVIEW QUESTIONS

1. Why should people be concerned about nonindigenous species? How do they affect ecosystems?

2. How can the transfer of invader species be controlled or stopped in the Great Lakes or elsewhere in the world? Draft a piece of legislation that your group thinks could be enacted to stop exotic species from invading the Great Lakes.

3. Identify as many Great Lakes jobs as possible that are impacted by invader species. (Some impacts may be positive; that is, new jobs may have been created by the newcomers.)

EXTENSIONS

1. Do research on controls that have been tried on various invader species and report on their successes or failures. Brainstorm a creative way to control one of the invaders.

2. Draw a humorous cartoon depicting the problem of invader species. (Example: A zebra mussel looking for a place to attach on an already-overcrowded lake bottom, a white perch nudging out a yellow perch, purple loosestrife choking other plants, etc.)

REFERENCES

Michigan Sea Grant. Spiny Tailed *Bythotrephes*. Its Life History and Effect on the Great Lakes (booklet). *Upwellings* Vol. 11 (3), Summer 1990 Vol. 14 (1), Winter 1992.

Michigan DNR. *Zebra Mussels in Lake Michigan: What recreational boaters and anglers should know* (brochure). Office of Great Lakes, P.O. Box 30028, Lansing, MI 48909.

Ohio Sea Grant. *The Spiny Waterflea,* Bythotrephes. *A newcomer to the Great Lakes.* Dave Berg. 2 pp. FS-049.

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Minnesota Sea Grant. *Seiche*, Spring 1992 — Eurasian milfoil: Can it be controlled?

Answers to Review Questions

1. Invading species threaten to change present ecosystems, often in unpredictable ways. Because invaders frequently do not have predators, they often have the ability to disrupt the existing ecological balance and dominate an area. Consider the effects of European humans after their introduction to North America. How many other species have humans displaced?

2. Bilge water is critical to the spread of invaders. Have students brainstorm different ways that invaders can be introduced and possible methods for preventing their spread.

3. Increased numbers of researchers are needed to study the potential impact and spread of the invaders. There could be new public water systems and industry jobs to keep pipes clean. Fishers will be affected because the type and quality of catch (fish size and health) will be different. Beach cleaners would be needed to get rid of dead fish, and boat cleaners will be in great demand to protect boats from invaders (potentially by developing and applying special toxic paints that will prevent zebra mussels in particular from adhering to boat hulls). Recreation facilities will most likely also experience some increased business because of the added water clarity that zebra mussels cause by filtering water, but may also lose some business because of decreased fishing opportunities. Park systems and gardeners must be concerned, because invader species will compete with the native vegetation and wildlife.

For additional activities

This activity was selected from ES-EAGLS: *Life in the Great Lakes*, 1997. To order the complete volume, contact Ohio Sea Grant Publications, 1541 Research Center, 1314 Kinnear Rd., Columbus, OH 43212. Phone 614/292-8949. 1997 cost $8.

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INVADER #1

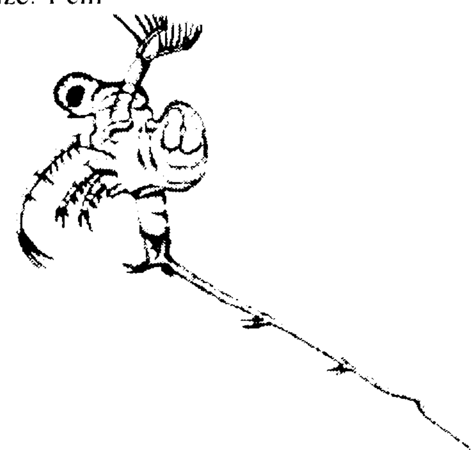
Zebra Mussel (*Dreissena polymorpha*)
Adult size: 1-4 cm long

INVADER #2

Sea Lamprey (*Petromyzon marinus*)
Adult size: 3 feet (91 cm)

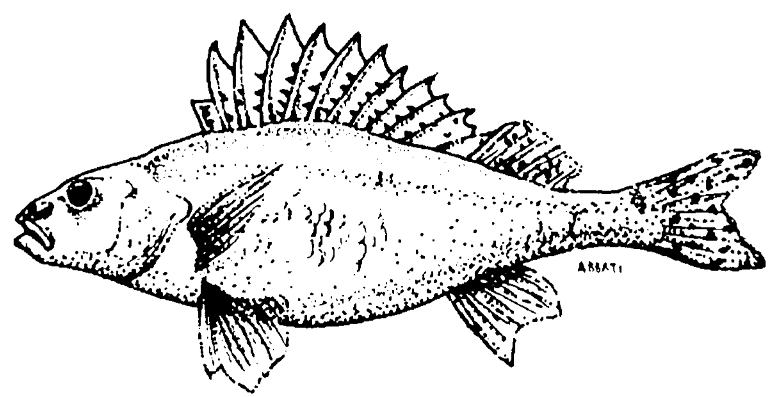
INVADER #3

Spiny Water Flea (*Bythotrephes cederstroemi*)
Adult size: 1 cm



INVADER #4

River Ruffe (*Gymnocephalus cernuus*)
Adult Size: usually less then 15 cm long



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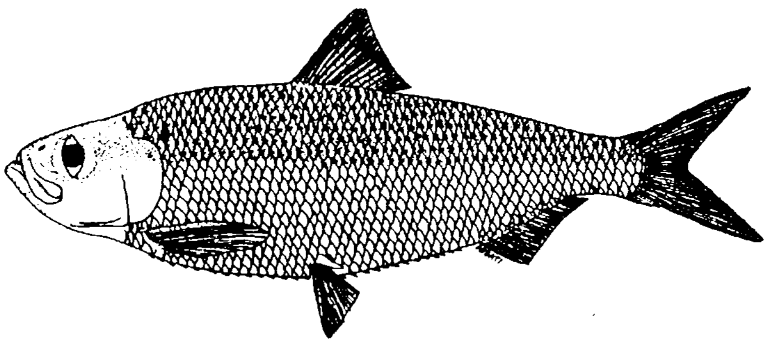
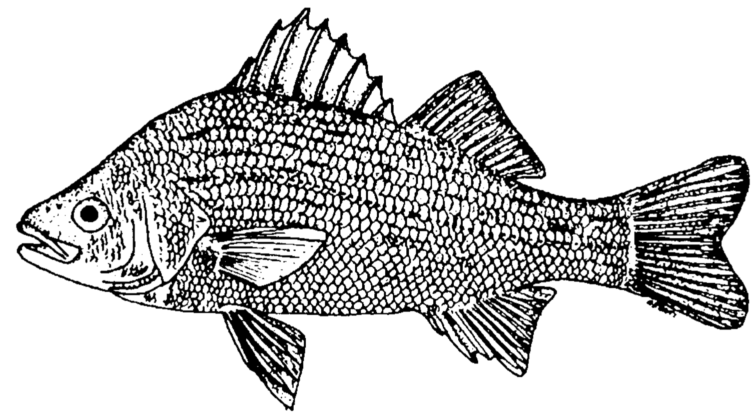
INVADER #5

Alewife (*Alosa pseudoharengus*)
Adult size: 3 cm



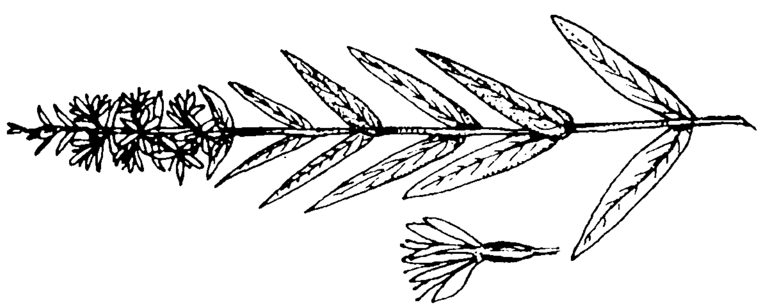
INVADER #6

White Perch (*Morone americana*)
Adult size: 30 cm (20 cm is more common)



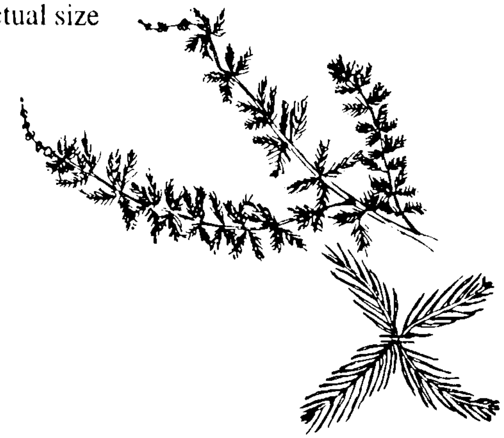
INVADER #7

Purple Loosestrife (*Lythrum salicaria*)
Adult height: .5 to 2 meters tall



INVADER #8

Eurasian Watermilfoil (*Myriophyllum spicatum*)
Leaflet is actual size



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INTRODUCTION

Originally it came from the Caspian Sea region of Poland, Bulgaria, and Russia. Canals built during the early 1800s allowed it to spread throughout Europe. By 1830 it had invaded Britain. First introduction into the Great Lakes was about 1985, when one or more transoceanic ships discharged ballast water into Lake St. Clair. Freshwater ballast from a European port likely contained larvae and possible yearlings. Being a temperate, freshwater species, it found the plankton–rich Lake St. Clair suitable as a habitat.

INTRODUCTION

Arriving from the freshwater and brackish water in northern Europe, this invader was discovered in Lake Superior in 1986. It is assumed that it "hitchhiked" in ballast waters from Europe and Asia. In 5 years, its population reached 1.8 million adults, making it the most abundant fish in the Duluth harbor. This bottom feeder can reproduce in its first year and the females may lay 13,000 to 200,000 eggs per season.

INTRODUCTION:

Originally, it came from the Atlantic Ocean, the St. Lawrence, and Hudson Rivers, and their tributaries for spawning, and possibly Lake Ontario. It swam from Lake Ontario into Lake Erie through the Erie and Welland Canals, gaining entry into the upper Great Lakes by attaching to hulls of boats.

INTRODUCTION

A native of northern Europe, it made its way into Lake Huron in 1984 and was present in all Great Lakes by 1987. It is believed to have been brought over in fresh water or mud in ballast water of European freighters from Eastern Baltic Ports, as studies show that the Great Lakes species closely resembles the species in the ports of Finland and St. Petersburg (the former Leningrad).

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INTRODUCTION

This species was intentionally imported from Northern Europe over 100 years ago, because its hardiness and beautiful flowers were popular with landscapers, florists, and gardeners.

INTRODUCTION

It came from Europe, Asia and North Africa and was introduced into North America as an aquarium plant. It has since spread to 37 states and 3 Canadian provinces.

INTRODUCTION

Coming from the salty Atlantic Coast, this invader migrated through water routes, including canals in New York State and the St. Lawrence River. It swam into the upper Great Lakes through the Welland and/or Erie barge canal before 1931.

INTRODUCTION

From saltwater areas of the Atlantic Coast, this invader moved up the Hudson River and via various canal systems into Lake Ontario and Lake Erie.

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ECOSYSTEM IMPACT

This is a large plankton form that eats the smaller plankton, thereby competing with small fish for their food source and affecting their survival and growth rates. Its spiny tail prevents young fish from swallowing it, thus removing it from the food chain. It is an invader species so new that it may take years to determine its total impact.

ECOSYSTEM IMPACT

It is called "the beautiful killer," because its dense roots choke waterways as it competes with other vegetation. It spreads quickly, crowding out valuable plants that provide food for migrating waterfowl, and destroys habitat for almost all other forms of wetland life.

ECOSYSTEM IMPACT

Only about 8 inches long, this perch-like fish has no value as a sport or food fish. It is less temperature-dependent than perch and tolerates more polluted areas. It also can find hidden prey in soft sediments more efficiently than its competitors. This fish is not preferred by predators because of its spiny fins. It displaces sport and food fish, especially yellow perch and walleye, yet is not readily consumed in the food web. This invader made up 90 percent of the fish population in the Scottish lake, Loch Lomond, only 9 years after it was introduced.

ECOSYSTEM IMPACT

Forms thick mats that choke out native aquatic vegetation. It disrupts all forms of water recreation—boating, swimming, and fishing.

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ECOSYSTEM IMPACT

It destroys valuable fish, especially lake trout, by attaching with its sucker-like mouth to suck out the blood and body tissues. It upsets the ecological balance by removing top predators, allowing for explosion of the populations of smaller fish such as alewives. It had great economic impact on the commercial fishing industry of the Great Lakes during the 1950s.

ECOSYSTEM IMPACT

Suspected to be partially responsible for the decline of Lake Erie's yellow perch because of competition.

ECOSYSTEM IMPACT

It filters the plankton from the water, binding what it doesn't use into pellets that cannot be used by other plankton-feeding organisms. It accumulates on objects such as boat hulls and underwater pipes, clogging valves of both industrial and municipal water intake sources.

ECOSYSTEM IMPACT

Large numbers die off in spring and summer because of electrolyte imbalance from living in fresh water. These die-offs clog municipal and industrial intake pipes and foul beaches. In 1967 bulldozers had to remove 50,000 tons of the rotting fish. The sea lamprey enabled this invader to thrive in Lake Erie by killing lake trout and other fish at the top of the aquatic food chain. After the sea lamprey arrived, this invader proliferated. Between 1960 and 1966, for example, they went from representing 8 percent to 80 percent of Lake Michigan's fish by weight. Presently this invader is food for larger game fish.

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Answers to Cards

Invader 1: Zebra mussel (*Dreissena polymorpha*)
Introduction: Originally, it came from the Caspian Sea region of Poland, Bulgaria, and Russia.
Ecosystem Impact: It filters the plankton from the water, binding what it doesn't use into pellets.

Invader 2: Sea Lamprey (*Petromyzon marinus*)
Introduction: Originally it came from the Atlantic Ocean, the St. Lawrence and Hudson Rivers.
Ecosystem Impact: It destroys valuable fish, especially lake trout, by attaching with its sucker–like mouth.

Invader 3: Spiny Water Flea (*Bythotrephes cederstroemi*)
Introduction: A native of northern Europe, it made its way into Lake Huron in 1984.
Ecosystem Impact: This is a large plankton form that eats the smaller plankton.

Invader 4: River Ruffe (*Gymnocephalus cernuus*)
Introduction: Arriving from northern Europe, this invader was discovered in Lake Superior in 1986.
Ecosystem Impact: Only about 8 inches long, this perch-like fish has little value as a sport or food fish.

Invader 5: Alewife (*Alosa pseudoharengus*)
Introduction: Coming from the salty Atlantic Coast, this invader migrated through water routes.
Ecosystem Impact: Large numbers die off in spring and summer because of electrolyte imbalance.

Invader 6: White Perch (*Morone americana*)
Introduction: From saltwater areas of the Atlantic coast, this invader moved up the Hudson River
Ecosystem Impact: Suspected to be partially responsible for the decline of Lake Erie's yellow perch

Invader 7: Purple Loosestrife (*Lythrum salicaria*)
Introduction: This species was intentionally imported from Northern Europe over 100 years ago.
Ecosystem Impact: It is called "the beautiful killer," because its dense roots choke waterways.

Invader 8: Eurasian Watermilfoil (*Myriophyllum spicatum*)
Introduction: It came from Europe, Asia, and North Africa as an aquarium plant.
Ecosystem Impact: Forms thick mats that choke out native aquatic vegetation.

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How did it get here?

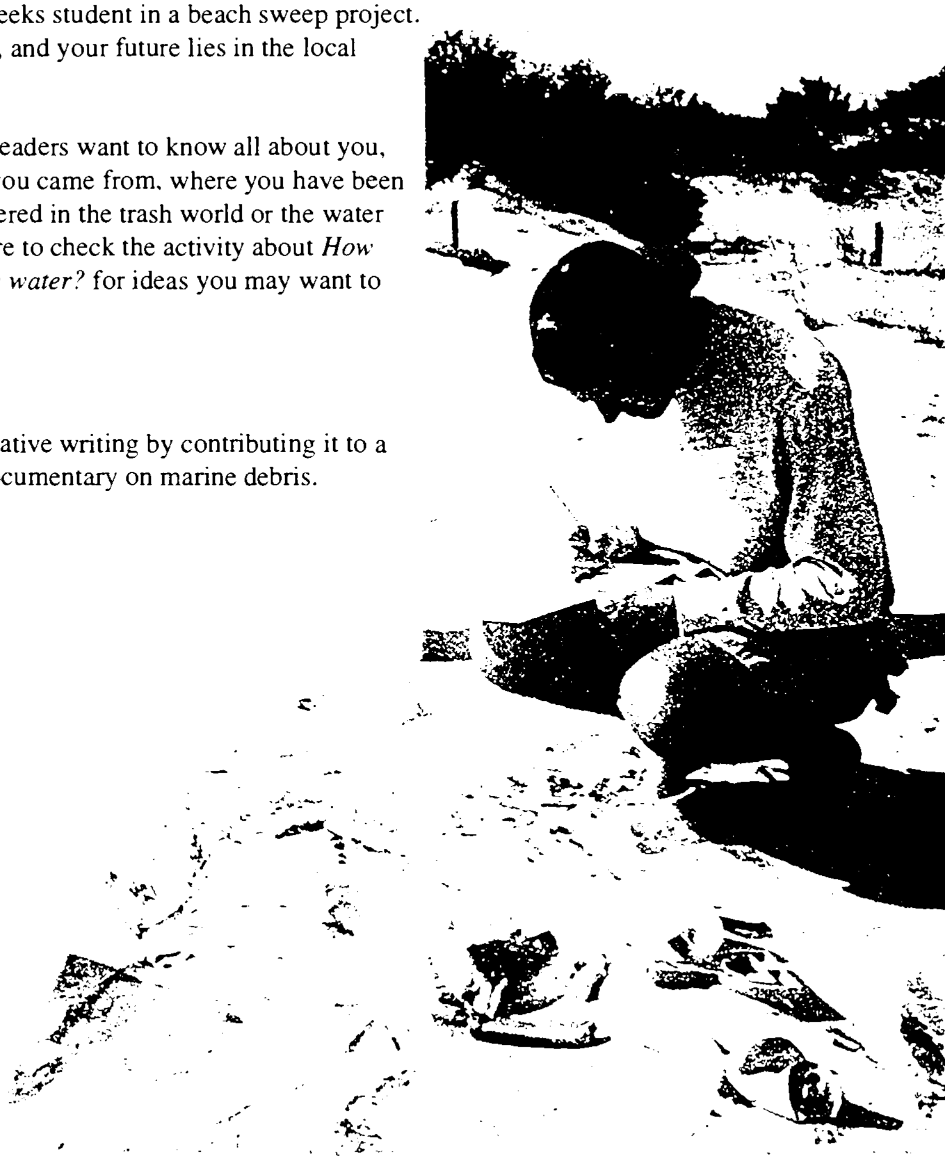
PROCEDURE

You have learned about how some of Lake Erie's nonindigenous species got into the lake, and perhaps you have examined the ways boats and fishing contribute to the debris found on beaches. Imagine now that you are a piece of marine debris and have just been collected by a Coastweeks student in a beach sweep project. Your trashy travels are over, and your future lies in the local landfill or incinerator.

Write your memoirs. Your readers want to know all about you, what you look like, where you came from, where you have been and what you have encountered in the trash world or the water world along the way. Be sure to check the activity about *How does debris move in surface water?* for ideas you may want to include.

SHARE YOUR WORK

Let others know of your creative writing by contributing it to a book of stories or a class documentary on marine debris.



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What is the impact of beach debris?

Whenever people talk about the future they form a mental image of what things will be like. They think about themselves and the things they know about, and in their imagination build a new picture of what they can expect. As we consider the impacts of beach litter, there are a number of ways of visualizing those changes.

The Earth Systems approach to science emphasizes connections and interactions. As a pretest/posttest assessment of learning, this activity will show how much growth has occurred in such concepts through use of the materials in this volume. Knowing how natural events affect their lives, students can infer a wide range of environmental impacts in the Great Lakes, including beach debris.

Earth Systems Understandings

This activity focuses on ESU #4 (interactions of Earth subsystems).

Source

The activity was adapted from "What Great Lakes factors will increase and what will decrease as a result of global warming?" from *GLIMCES*, 1995. The original idea is from ZPG's *More or Less* game.

Materials

- blank wall, chalkboard or bulletin board
- 1 card labeled BEACH LITTER
- 20 cards labeled MORE (light color, such as yellow)
- 20 cards labeled LESS (same color)
- 35-40 impact cards with things that could change as a result of beach litter (contrasting light color, such as green)

Objectives

After completion of this activity, students should be able to

- List and explain many potential impacts of beach debris.
- Discuss various interpretations of the possible debris impacts.

Procedure

1. Gather or construct the materials listed. Before beginning the activity, create impact cards (factors or activities which could be affected by beach debris). These impact cards should include both scientific impacts and social impacts (focus on things that can go up and down). Some possible impact cards might include those listed on the next page.

2. Make a large card that says BEACH LITTER and tape it in the center of a blank wall. Make a stack for MORE cards and a stack for LESS cards. Spread the impact cards out over a large table so most of them can be seen at one time.

3. Invite students to come forward one table or row at a time and select an impact card which they feel is the direct results of a previously mounted card. They should then select either a MORE or a LESS card to indicate whether the result would be an increase or a decrease. Students must be able to justify the position of the cards they add, and their choice of MORE or LESS impact.

4. As students use these cards, it will become apparent that there are various interpretations of the impacts. Have the class discuss all interpretations.

5. Assessment can be done by having each student select a chain of 8 cards, diagram them in a portfolio, and give a possible interpretation of the links illustrated

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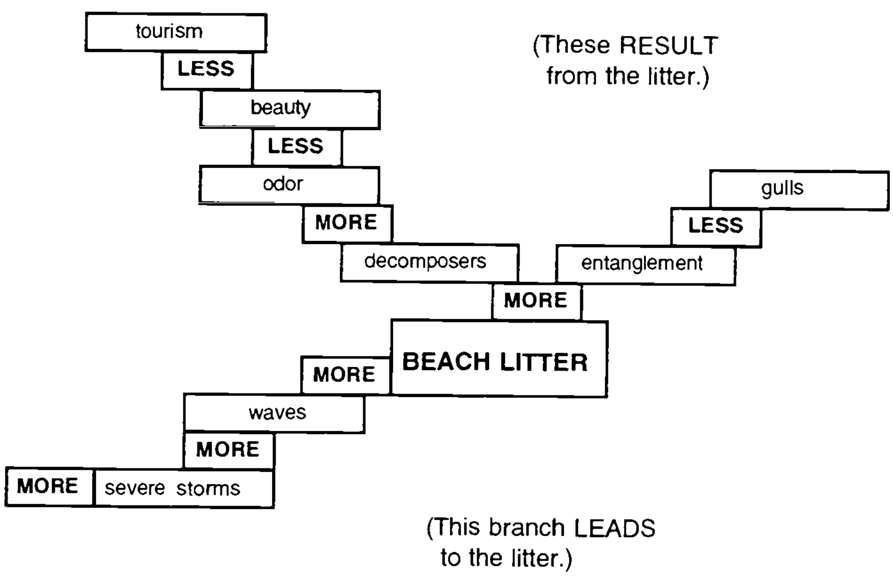
MAKE CARDS FOR THINGS THE GREAT LAKES REGION MIGHT HAVE "MORE OR LESS" OF WITH BEACH LITTER, SUCH AS THESE FACTORS:

Shipping	Cooperation	Law	Longshore Current
Odor	Shoreline Development	Water	Waves
Shoes	Injuries	Entanglement	Severe Storms
Smoking	People	Pollution	Tourism
Biological Diversity	Oxygen	Sun	Fishing
Gulls	Ugliness	Plastic	Beauty
Recycling	Biodegradation	Decomposers	Swimming

A SAMPLE OF HOW THE GAME MIGHT PROCEED:



EXTENSIONS AND ALTERNATIVES

This activity can also be used at various stages of a unit. For instance, it can introduce a new topic and related it to previous ones, or it can be a culminating activity to draw all aspects of a study together. In addition it would be an interesting evaluation to take a Polaroid photo of the concept map created at the beginning of a unit and compare it with the map produced at the end. Some teachers use this as a small group activity with 3x5 cards. Groups can prepare a written or oral presentation of their maps, analyzing the thinking about interrelationships that produced the array.

[NOTE: This activity can be done on a sandy beach if there is not much wind. We used old corrugated cardboard and stood the cards up in the sand. Don't forget to remove the materials when you finish!]

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What evidence of glaciation and geologic processes can be found on Great Lakes beaches?

What kinds of substances make up the Great Lakes shoreline? What makes up the sediment? What do we walk on as we stroll along the beach? This activity investigates the characteristics of different pebbles and rock pieces along Great Lakes shores.

You will be examining data from different sections of a Great Lakes shoreline to study composition of beach sediments. Follow the guidelines to organize the data, analyze it, and provide some interpretations.

OBJECTIVES

When you have completed this activity, you should be able to:

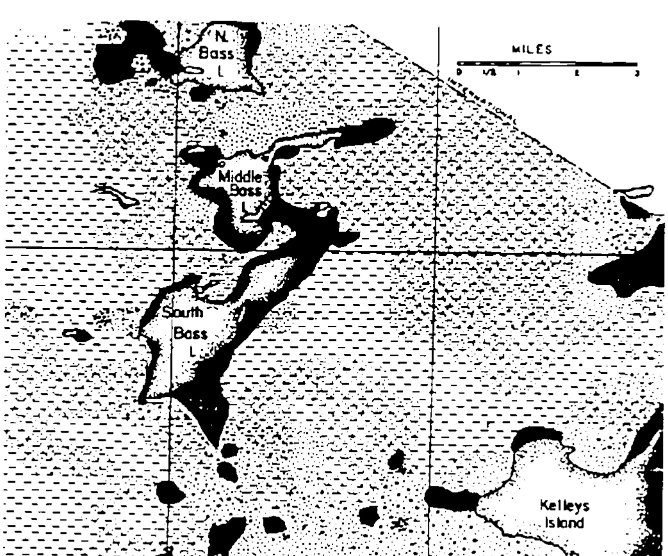
- Distinguish between general types of rocks found on a Great Lakes beach.
- Analyze factors that might determine rock types at a specific location.
- Explore options for presenting data.

PROCEDURE

Work in groups to cover as many different areas of the shoreline as possible.

Collect Samples

1. Data Collection: You will collect samples from different areas of shoreline. Locate each of your sampling stations on a map of the lake. Note which direction the shore faces at that site.



Source

Selected from ES-EAGLS: *Land and Water Interactions*. 1996. Order from Ohio Sea Grant Publications. 1997 cost $8.

Earth Systems Understandings

This activity uses ESU 3 (science methods and technology), ESU 4 (to investigate evidence of natural interactions), and ESU 5 (change through time).

Materials

- Hand lens.
- Geologist's hammer.
- Graph paper.
- Dilute HCl.
- Pencil, ruler, paper.

Student Review

In what ages of rock are limestone and dolostone found? What are the ages of predominant bedrock types in your area of the Great Lakes? Determine the possible age of other rocks in your sample. In this activity, you practice identifying samples along a Great Lakes shoreline similar to the activity "How were sedimentary rocks in the Great Lakes basin formed?"

Rock types around the Lake Erie islands

DOLOMITE/LIMESTONE
SAND(>90%)
GRAVEL(>90%)
MUD(>90%)

Artist: Sue Abbatti, from *Great Lakes Education: A Manual for Aquatic Ecology Studies at Franz Theodore Stone Laboratory*. Ohio Sea Grant, 1983.

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Teacher's Note

An easy way to sample a beach is to randomly select a spot on the rocky shore to sit down, facing the water, and reach down to your sides with both hands. Gather all the pebbles you can hold in two hands and test them for types. The number collected is a good relative size measure.

Student Observations

Observe the location of larger and smaller pebbles relative to the water's edge. For an example of how larger and smaller sediments settle at different rates, see the demonstration in the activity "How were sedimentary rocks in the Great Lakes basin formed?"

You may observe quartz along the dunes of the lakes. Quartz is more resistant to weathering than other rocks.

Answers

4. It may be challenging to identify types of rocks. You may want to become familiar with the local rocks typical to your specific area before trying to identify them in the field. Refer to the activity "How were sedimentary rocks in the Great Lakes basin formed?" for examples of rocks and for geologic evidence that may suggest the kinds of rocks present at a specific site. A conglomerate will consist of several different kinds of pebbles cemented together, and crystalline rocks may sometimes display different types of minerals in one pebble.

5. This is especially important in the Lake Erie island region, where some islands are limestone and some are dolostone.

2. Decide on a sampling technique that will yield a good representation of the kinds of rocks present. Determine what you think is the best way to achieve a good distribution of samples from different areas.

3. Divide into groups so that different sections of the beach can be examined and collect pebbles from different areas of the shoreline. Note and record the wave action at your sample site. If you took more than one pebble sample at each station, indicate the position of samples on the map.

Analyze Samples

4. Which pebbles in your sample appear to be homogeneous, or made of the same material throughout the sample? Which types of pebbles consist of many different pieces of rock cemented together? Are there pebbles in which you notice a repeating pattern? How many of each kind do you have in the sample?

5. Break each pebble with a blunt hammer and drop a small amount of dilute HCl on the fresh surface. If the pebble is limestone, it will fizz vigorously. If dolostone, it will fizz very slowly. Other types of rocks will not fizz. Count how many original pebbles you had before breaking them that are dolostone and limestone; decide which others are crystalline, conglomerate, etc. Use your pebble count for the next step.

Graph the data

6. As a class, plot the number of rocks of given types in each sample based on categories in the included table (conglomerate, limestone, dolostone, and crystalline – igneous and metamorphic – rocks, etc.). Use a single bar divided proportionally by the number of pebbles in the sample or another technique as appropriate. If you selected a sample with many large pebbles, you will have a short bar; and if your sample contained various small pebbles, it will be a taller bar. You will get an idea of the size of pebbles, in each beach sample from your graph. If you did more than one sediment sample at a site, use the sample nearest the water's edge for a graph.

7. Are there any fossils in your collection? Ask local experts for help in identifying them or use a key to try to name the fossils you have found.

8. Is there other glacial evidence relating to topography in the sample area? Draw or describe the topography you notice,

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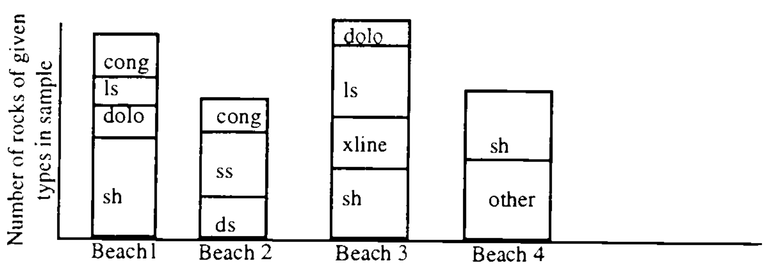
for example the shape of the landscape that might suggest the action of glaciers in the past, or the presence and orientation of glacial grooves or striations. Are there glacial erratics present in the local bedrock? Which pebbles in your sample may have been carried by glaciers to the site? (Hint: Which pebbles appear different than the native bedrock?)

9. Develop a report that includes:
   a. Data collection methods.
   b. Methods used to analyze rock samples.
   c. Description of any patterns you see in the data, both for glacial direction, rock types and size.
   d. Possible explanation for any patterns you see.
   e. Justification of those explanations. What other information do you have that leads you to choose one explanation over another? What other information do you need to see if your explanation is valid?

One way to graph:



In your discussion, consider data that would provide information about island bedrock, direction of wind, effect of wind, etc. Explain why there would be differences in rock size on the same beach, on a different beach nearby, no obvious beach materials on some shores, etc.

REVIEW QUESTIONS

1. Why are glaciers able to transport rock and sediment long distances? How can you tell when looking at a section of beach if pebbles came from glacial deposits?

2. Based on this and previous activities, what are the major ways we distinguish rock types – sedimentary, igneous, etc.? What are the different ways rocks form?

3. How does the action of water on beaches affect beach composition and morphology? Is it possible that these beach characteristics could change seasonally?

Answers

8. Ideally, students should find an area such as an outcropping where they can view the bedrock beneath the soil layer for glacial deposits. An erratic is a rounded rock that does not match the local bedrock and perhaps was deposited by glaciers.

Glaciers are able to keep sediments suspended over long distances and time periods. Also glaciers grind rocks, and there may be evidence of this on the surface of larger rock pieces or rocky beach walls. Rocks carried in by glaciers may be different from the native bedrock. Gathering data from more than one beach is ideal for this exercise.

Teacher's Note

Ideally, this activity would be conducted on several beach areas accessible by the classroom. Students collect a variety of specimens from as many different areas as possible.

Alternatively, collect the beach pebbles yourself and bring in enough for the class to analyze, or develop a simulated data set.

The movement of water causes various effects on rock walls and beaches. Water can increase changes in rocks by freezing and expanding; thus, changes in seasons will have an effect on beaches.

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Table 1. Characteristics of Rock Samples.

Date: Site:

Morphology of beach (slope, width, etc.):

Pebble count

Type	cong	ss	sh	ls	dolo	xline	other
Number							
% of total							

Notes (on size, and shape of pebbles, etc.):

Key: cong (conglomerate), ss (sandstone), sh (shale), ls (limestone), xline (crystalline – igneous and metamorphic).

Extensions

1. What is a petrologist? a geomorphologist? Why might such careers be important in the Great Lakes region?

2. Accurately weigh a few pieces of limestone and record the weights. Take a cold carbonated drink and place the weighed pieces of limestone in it. Cap the drink tightly and place it in the refrigerator. After a few days remove and dry the limestone chips. Reweigh them to see if their mass has changed. If it has changed, test the carbonated drink for calcium ions by adding some saturated ammonium oxalate solution. A milky white precipitate denotes the presence of calcium in the drink. Add ammonium oxalate to a fresh carbonated drink to see if a reaction takes place without the presence of limestone pieces.

3. Freeze pebbles in water in a milk carton. After it is frozen, remove the bottom of the milk carton. Drag the exposed surface over different materials such as wood, compacted clay, and plastic. This simulates the action of a glacier. Record the effects you see. Observe the scouring effects as you add force to the motion across surfaces.

References

Earth Science Curriculum Project, American Geological Institute, William H. Matthews, et. al. 1987. *Investigating the Earth*, 4th ed. Boston: Houghton Mifflin Company, illus. 560 pp. See teacher's guide and text.

Ramsey, William L., et. al. 1989. *Modern Earth Science*. Austin, Texas: Holt, Rinehart and Winston Inc., 592 pp.

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What causes the shoreline to erode?

Shorelines along the Great Lakes vary in the nature of their sediments and erodibility. Natural causes of erosion include waves, currents, and effects of wind and storms on shoreline processes. We can simulate the processes of shoreline erosion for an understanding of the ongoing changes that occur in coastal areas.

OBJECTIVES

When you have completed this investigation you will be able to:

- List major natural forces of erosion along the lake shore.
- Describe how the rate of erosion differs with different materials.

PROCEDURE

In teams of three, follow the procedure below.

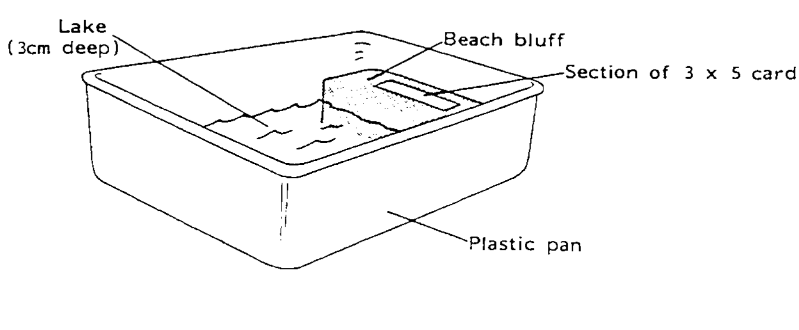
A. In the end of one of the plastic pans, place three handfuls of wet sand.

B. Using a piece of board, mash the sand up against the end of the pan and flatten the top. Make this "beach bluff" about as wide as it is high.

C. Repeat Steps A and B with a second pan, building a beach bluff made of wet soil.

D. In one end of the third pan make a stack of rock pieces that will represent a rocky shoreline about the same size as the other bluffs.

Figure 1. Shoreline Model.



Source

Modified from OEAGLS EP-7, "Coastal Processes and Erosion," by Beth A. Kennedy, Newark Public Schools, Ohio, and Rosanne W. Fortner, Ohio Sea Grant Education Program, The Ohio State University.

Earth Systems Understandings

This activity explores ESU 4 and 5 (the impact of land and water interactions on shorelines over time). Extensions address stewardship of coastal resources using ESU 2 and 3 (scientific methods and planning). Using ESU 6 students can consider how coastal processes relate to Earth's position in a larger universe.

Materials

Divide the class into teams of three, giving each team the appropriate materials. Each lab team should be supplied with

- Three rectangular plastic dishpans or plastic shoe boxes.
- One piece of board (2 x 4 or plank) as long as the width of the dishpan's floor.
- One piece of board half as long as the width of the pan.
- About 1 liter of sand per team.
- 1 liter of potting soil per team.
- Several pieces of rock 5-10 cm long.
- 3 x 5 note card cut in three long strips.
- Ruler to measure wave heights.
- Access to a supply of water.
- Each student will need a pencil or pen for recording data and answering questions.

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Teacher's Overview

Students examine how shoreline geology affects the rate and amount of erosion that occurs along the edges of oceans or lakes. They conduct an experiment comparing the stability of three geologically different beach bluffs as they are attacked by waves.

In recording data, it is suggested that the number and height of waves be recorded only once for each shore type, when the bluff collapses.

Additional Method

Students can use a fan to generate wind and produce waves, simulating actual conditions on a lake.

Suggested Approach

To help cut down on the amount of equipment needed, the activity could be done in large groups or by a single group of students acting as demonstrators. Stress that the water used in Step E be poured in slowly; otherwise beach bluffs may begin to collapse before waves are generated.

Be sure to provide an appropriate place to dispose of the muddied water, preferably outdoors away from the school building.

You should now have three "beach bluffs" of various types and sizes of material. The three pans represent lakes.

E. Hold the pieces of board up against the sand bluff to protect it while you slowly add water to the empty end of the pan. Create a lake about 1-1.5 cm deep. Remove the board gently when the lake water is still.

F. Repeat Step E to create lakes in front of the soil and rock bluffs.

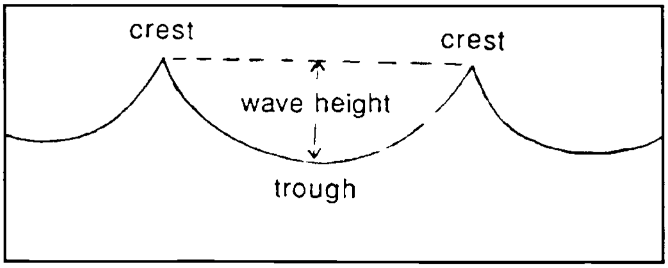
G. Gently place a strip of note card flat on top of each bluff.

H. You are now ready to act as the wind, making waves and causing erosion on the shoreline. Using a ruler or the pieces of board, make waves that move toward the beach bluff from the opposite end of the lake. Start gently, counting the number of waves you produce. Then gradually increase the strength of your waves as if the wind were becoming stronger. Record what happens to the beach bluffs as you repeat this process in each lake. Put your information in a Data Table that shows the number of waves before bluff collapse, size of waves, and effects on the bluff for each type of shore material.

I. When the section of note card slips toward the water, your bluff has collapsed. If collapse has not occurred after 100 waves, stop and record your observations of the bluff's condition. Put this information in the Data Table.

NOTE: To estimate the height of waves, find the distance from the top (crest) of the wave to the lowest part (trough) of the wave. Do not measure from the bottom of the "lake" basin unless the bottom is actually exposed as the wave passes by. Refer to Figure 2.

Figure 2. Determining Wave Height.



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Answer the following questions based on your results.

1. Which beach bluff is the least stable (collapsed first)?

2. Which beach bluff is the most stable (withstood the most waves)?

Some beach bluffs around the Great Lakes shore are actually made of sand and some of clay similar to the soil bluff you constructed. The rocky bluffs of the lake shore may be of limestone or a soft shale.

3. What type of beach bluff would you choose if you were building a cottage on the shoreline? Why?

4. Map 1 shows Lake Erie's shoreline. Cover the top half of the page. Based on what you have discovered about how different materials erode, answer the following questions using the lower map provided.

   a. Put X's on the sections of shoreline that are probably made of rock.

   b. Put O's on the sections of shoreline that are probably made of sandy material.

(You do not have to cover the shoreline with either X's or O's. The shape of the shore may not give you any clues about the type of material it has.)

   Uncover the top half of the page and check your predictions using the map of shoreline deposits.

5. Some points of land sticking out into the lake may be made of sand. What process is probably responsible for carrying the sand and depositing it there? (You may need to reread the introduction at the beginning of this activity.)

Answers

1. The sand bluff is the least stable. The small and fairly uniform grain size produces a permeable surface that is quickly penetrated and disrupted by the water. On the board, record wave heights and number of waves from different lab teams. Note that higher waves erode the bluff more quickly (fewer waves are needed).

2. The rock beach is the most stable because of the resistant nature of the rocks. Students may want to discuss which types of rocks would be more resistant to erosion. An interesting experiment could be designed by the class using small rock polishers (tumblers) loaded with different kinds of local rocks and processed simultaneously for the same number of days. Students should choose rocks depending on the lake region of study. Comparing the mass of rocks before and after the erosion would indicate which rock types were more resistant. However, you should mention that shale, though a rock, is quite erodible and would not be a good site for construction.

3. When erodible characteristics are considered, students should choose the rocky bluff as a building site. However, you should mention that shale, though a rock, is quite erodible and would not be as good a site for construction. At the end of the activity are transparency masters for use in illustrating the types of shorelands and beaches around the Great Lakes and a discussion of the possible uses made of these areas. Students who have completed the activity should be able to identify areas of potential erosion problems using the outline maps.

4. See the accompanying map for approximate locations of sandy and rocky shorelines. Student maps should be accepted if an attempt has been made to label shoreline sections. Points of land projecting into the lake are often labeled "X" by students, and cut away sections of shore may be labeled "O." A discussion of students' responses and the transparencies can lead to consideration of Question 5.

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Answers

5. The lake's longshore current, or littoral drift, is responsible for creating many of the points of land projecting into the lake. The "spits," as they are called, are made of sediments carried from other areas. The current direction produced by the prevailing winds determines which way a spit curves.

6. The points of land that form smooth curves out into the lake are generally sandy. Those with ragged or angular shapes usually have a rock base. The two lakeward projections surrounding the mouth of Sandusky Bay illustrate these differences. The Marblehead area to the west of the bay is limestone, and Cedar Point to the east is a sandy deposit.

7. In predicting future shoreline characteristics, it is hoped that students will apply what they have learned about coastal processes. Answers will vary, and the differences between predictions can furnish material for class discussion of erosion and deposition rates, the future of lake shore property, and how the shore could be protected. An outline map of all lakes is found at the back of this volume. Enlarge sections as needed.

For other activities

This activity was selected from ES-EAGLS: *Land and Water Interactions*. 1996. To order the entire volume, contact Ohio Sea Grant Publications, 1541 Research Center, 1314 Kinnear Rd, Columbus, Ohio 43212.

Lake Erie's Pelee Island is an interesting case in point. The island is rocky, but has a spit at its southern tip. Changes in the direction of the longshore current cause the spit to curve eastward at some times and westward at others. People sailing on the lake have referred to Pelee island as "the island that wags its tail."

6. How could you tell from their appearance which points of land might be sandy instead of rocky?

Erosion of coastal areas, as you have seen, occurs at different rates depending upon the material making up the shoreline. The same processes act upon the ocean as upon large lakes. Some of the coast of England, for example, has been worn back more than 3 km since the time of the Romans. The shore of Cape Cod retreats at the rate of 25 to 150 cm each year. These coasts are composed of relatively weak material, but the same process takes place more slowly in the hardest rock.

7. On the map on your work sheet, draw your prediction of how the Lake Erie shoreline will be shaped 100 years from now if the present rates of erosion and deposition continue. Select another of the Great Lakes and repeat steps 4-7 using the lake outline provided.

Review Questions

1. Explain how natural forces cause erosion along the Great Lakes. How do you think human actions contribute to coastal changes?

2. What types of shore materials erode faster? Slower?

3. Use a concept map to illustrate the present day land/water interactions along the Great Lakes coastline showing relationships between the factors involved in coastal processes.

Extensions

1. Do research to locate the largest cities along the Great Lakes. Also determine where the population densities are the greatest. Begin your search with GLIN on the Internet, or with the Great Lakes Atlas. What effect would these factors have on erosion rates along the shores?

2. How should decisions be made about potential shoreline uses and devices designed for shoreline protection? What interests should be considered in the decision-making process? What would you do if you could decide on the best way to use a section of shoreline? Draw a picture of what it would look like.

3. Extend your thinking to construct a concept map relating this activity with the position and action of Earth in space, i.e., the effect of the rotation of the Earth on wind generation, the seasons and their influence on storms, temperature, and coastal processes. Work in teams to create ideas to share with the class

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Teacher's Page

Example of student data table:

	Number of Waves	Height of Waves	Effects on Bluff
SANDY BLUFF			
SOIL BLUFF			
ROCKY BLUFF			

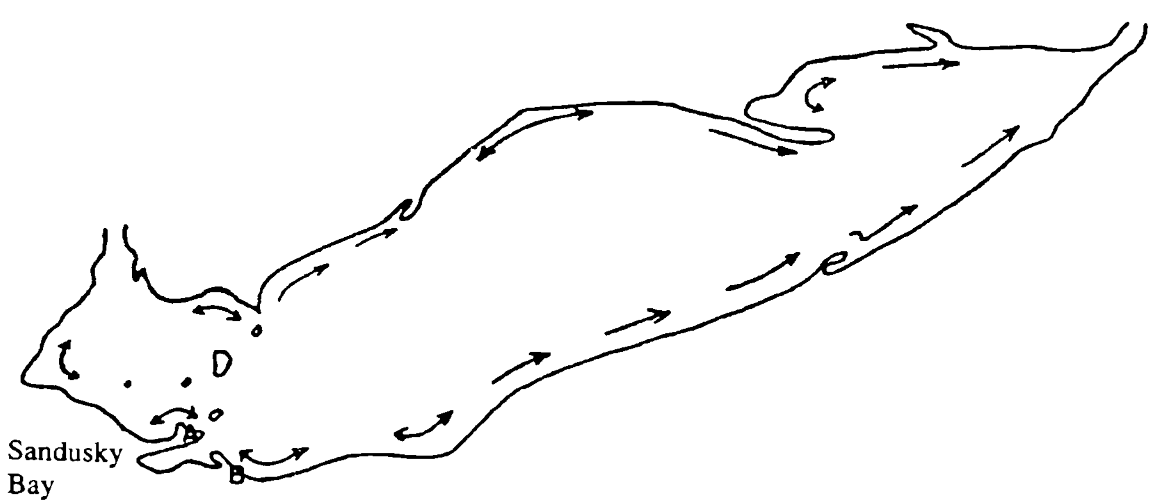
Figure 1. Comparison of Lake Erie Coastline Features.

Figure 1 shows how the rocky and sandy bluffs look in cross section. Rocky areas are generally steep and angular, while sandy bluffs have a gentle slope. The cross sections shown were taken at areas marked A and B on Figure 2.

A. Rocky bluff profile (Eastern end of Marblehead).

B. Sandy bluff profile (West of Huron, Ohio).

Figure 2. Net Direction of Littoral Transport, and Curvature of Spits in Lake Erie.



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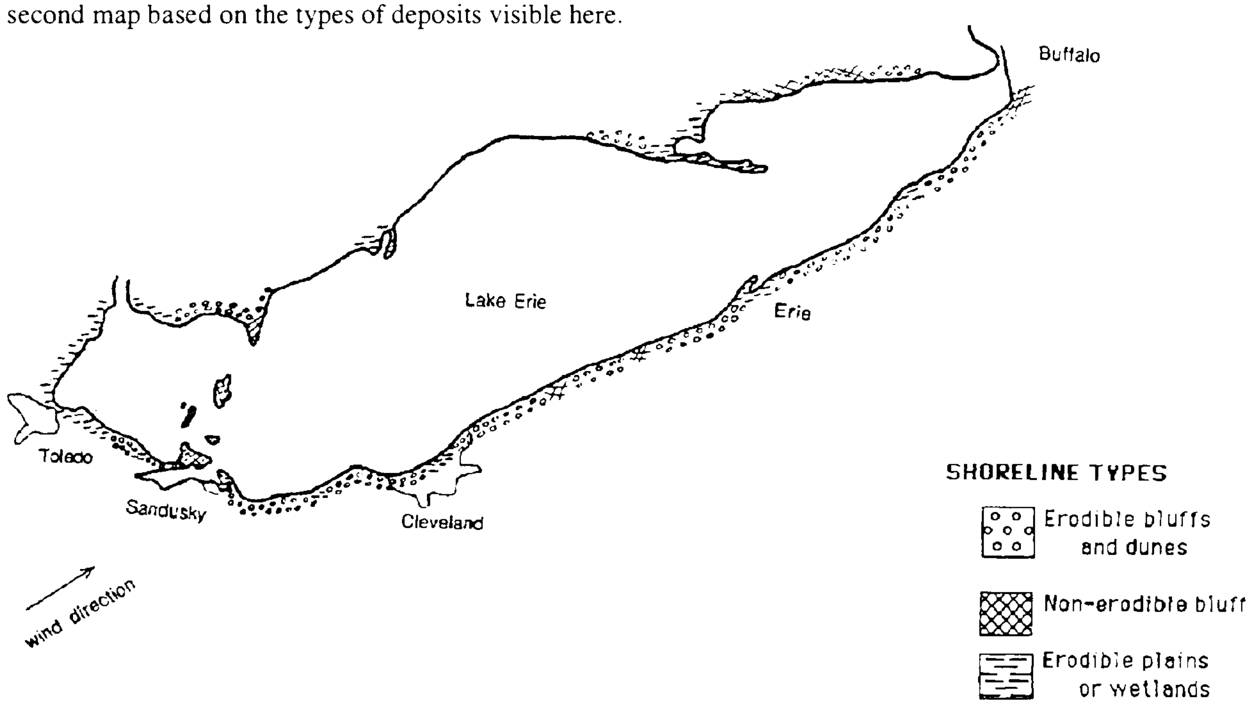
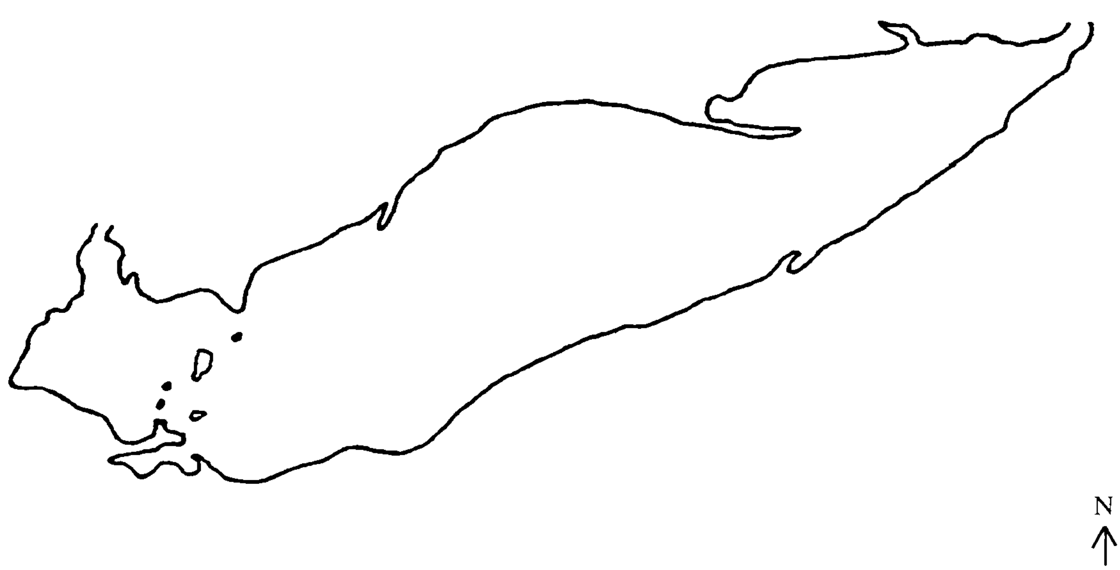
Map 1. Lake Erie Shoreline.
Below are the shoreline types surrounding Lake Erie. Make your prediction of the future shoreline on the second map based on the types of deposits visible here.



Predicted Shoreline of Lake Erie 100 Years From Now (Present Shape Given).



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How does debris move in surface water?

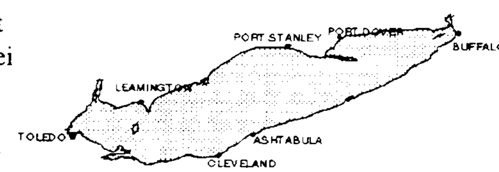
When longshore currents, storms, and the general flow of water through the lakes carry sediments from place to place and shape the characteristics of the coastline, they also carry marine debris. Before we knew about the impact of marine debris on wildlife, it was popular to put messages in bottles and make contact with finders on distant beaches, or tie messages to balloons to see where the wind carried them. Moving wind and flowing water are powerful forces, and sometimes great distances were covered by these messages.

Today we can simulate the movement of wind and water in much more sophisticated ways. The Great Lakes Forecasting System is a computer model that shows how winds, temperatures, waves and water levels interact and change over time in Lake Erie. The on-line information source at

http://superior.eng.ohio-state.edu

is updated every six hours, and has archived data so we can find out what happened in the past few years as well as what is happening now.

PROCEDURE



1. Assume that boaters in Toledo, Cleveland, Port Dover, Port Stanley, and Ashtabula have all had a great day painting thei boat hulls with a new paint that repels zebra mussels. They stirred the cans with plastic spatulas, but accidentally knocked those paint stirrers into the water. They know they should retrieve them, but can they?

   With this activity are three diagrams from the Great Lakes Forecasting System representing different days when this scene might have happened. Divide the class into five groups to represent the cities, and determine which days the current would bring the plastic debris back toward shore near their city.

2. Next assume the stirrers were wooden, and would float a long distance. They are also biodegradable, eventually, so the painters don't feel so bad about letting them go. Assume the current remains about the same for an entire day.

[Note: The length of the arrows is an indication of the speed of the wind.]

- Which day would carry them the greatest distance?
- Which stirrer can go the farthest on May 6?
- If each stirrer on Day 3 reaches the land, identify the shore-line site most likely to be the landing place for the stick from your group's city.

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3. The name will be publicized, but CMC has no means of taking action against debris sources. Perhaps public opinion can be brought to bear against them.

4. The beach WEST of Pelee would receive the debris.

   For rubber duckies, see *Science News*, September 15, 1994, or *EOS*, September 13,1994. There was also a spill of Nike sneakers in late 1991 that served as a way to track currents!

5. Answers will vary depending on what the map for today holds. Compare wind direction and other available data.

6. Again, answers will vary. In most cases the debris on the south shore of Lake Erie comes from areas west of where it is found. This is not always the case, however.

3. A Coastweeks cleanup crew will now have to collect the results of this adventure. If your marina's name is on the stirrer, the marina can be identified as the polluter. Is this a problem? What will happen?

4. An island hopper boat is going so fast in its July 31 cruise that some plastic cups accidentally blow off the deck and become marine debris. The boat is at the tip of Pelee Island. In what direction does the debris travel? What beach is likely to receive it if the current and wind remain the same? Read the story about the "rubber ducky spill" and what we learned about currents from an accidental marine debris incident!

5. Look at the GLFS data for TODAY. In which of the questions above would the answers be different using today's data?

6. Examine the GLFS data for at least ten days in the past month. If you find marine debris on your coastal area during Coastweeks, where might it have originated?

7. Are there ways you can tell how long a piece of debris has been on a beach? How?

Sharing your data

The computer diagrams given here are used as examples. Download and print a copy of today's data for comparison, and develop a Powerpoint or other computer slide show to demonstrate how a piece of debris would move in the case of several kinds of winds and currents. (Imbed the computer diagram in a computer slide, then draw over it to show your predictions.) You can also create animations of wind and current changes and display them this way to show how debris transport would work. Print out or project your work so others can learn from your examples.

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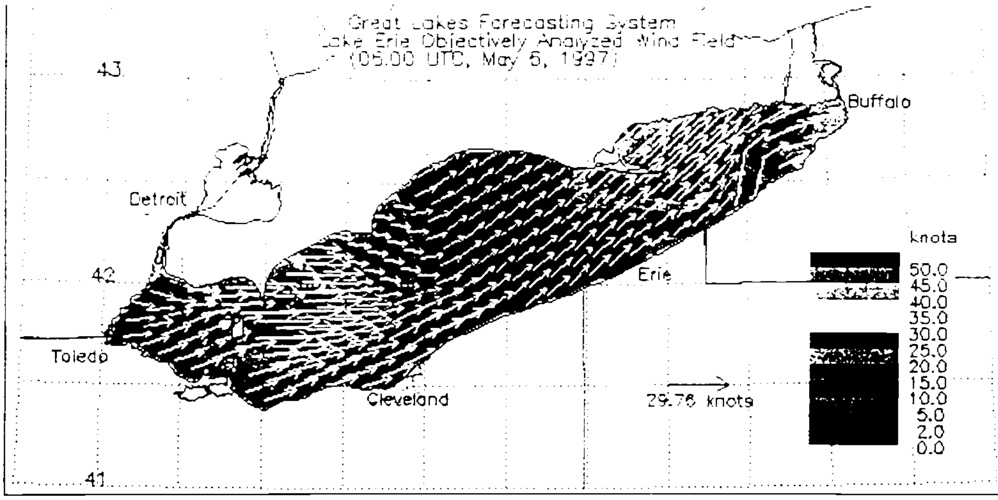
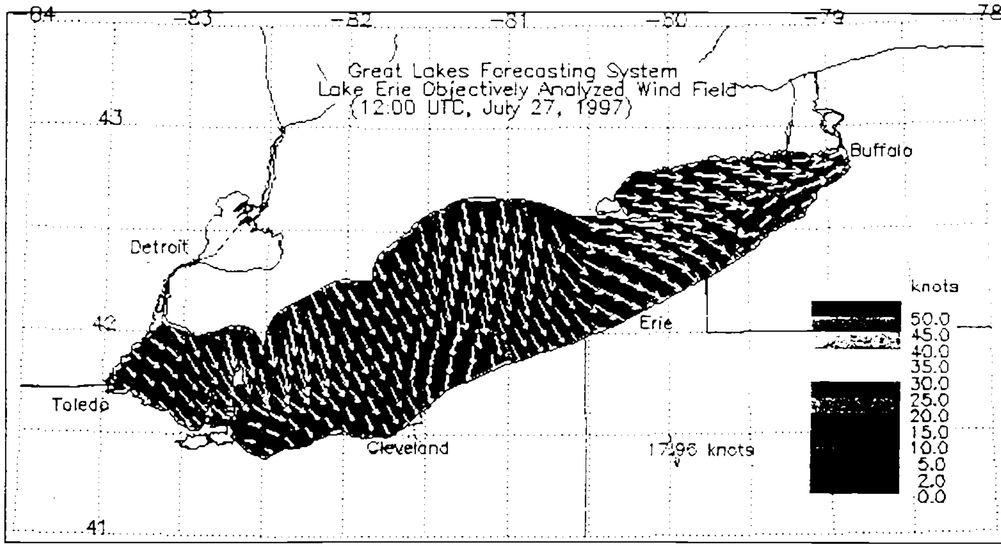
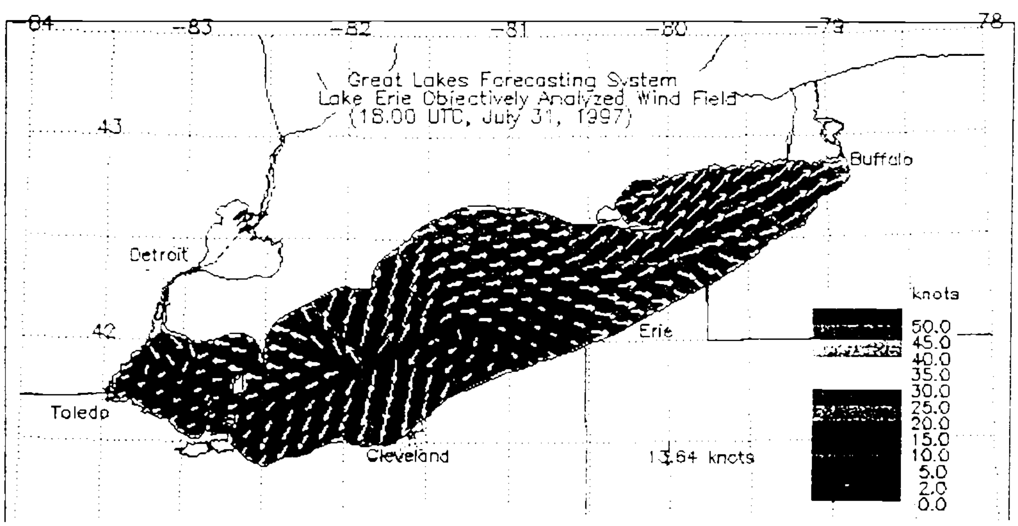
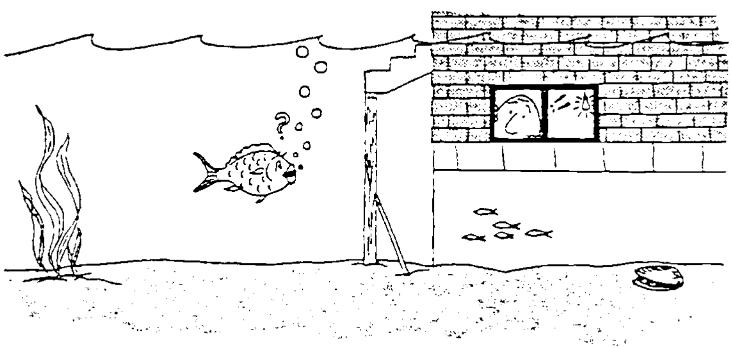

Great Lakes Forecasting System
Lake Erie Objectively Analyzed Wind Field
(05.00 UTC, May 5, 1997)
43
42
41
Buffalo
Detroit
Erie
Toledo
Cleveland
29.76 knots
knots
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
2.0
0.0


-84
-83
-82
-81
-80
-79
-78
Great Lakes Forecasting System
Lake Erie Objectively Analyzed Wind Field
(12.00 UTC, July 27, 1997)
43
42
41
Buffalo
Detroit
Erie
Toledo
Cleveland
17.96 knots
knots
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
2.0
0.0


-84
-83
-82
-81
-80
-79
-78
Great Lakes Forecasting System
Lake Erie Objectively Analyzed Wind Field
(18.00 UTC, July 31, 1997)
43
42
Buffalo
Detroit
Erie
Toledo
Cleveland
13.64 knots
knots
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
2.0
0.0

How do the levels of the Great Lakes change?

People like lake shores. There is something about the movement of waves against the beach, the sight of a sailboat on a clear day, and the ability to plunge into the water on a hot summer day that attracts people to the lake. Shores tend to become highly developed. Property values are high. Lakes, however, can be unpredictable. Storm-driven waves can destroy houses, especially if the level of the lake has risen since the houses were built. Is this a problem on the Great Lakes?



Source

Modified from OEAGLS EP - 5 "Changing lake levels on the Great Lakes" by Carolyn Farnsworth and Victor J. Mayer

Earth Systems Understandings

This activity focuses on ESU 3, 4, and 5 (science process, interacting subsystems and subsystems are evolving).

Objectives

When you finish this activity you will be able to:

- Determine whether lake levels of the Great Lakes change.
- Determine the effect of an increase in lake level.
- Identify possible causes of changes in lake level.

Materials

- Topographic map of Eastlake, Ohio.
- Graph paper.
- Ruler.
- Pencil.

Procedure

Records of the level of the water in Lake Erie have been kept for over 100 years. Figure 1 is a graph of the average monthly level of Lake Erie measured in meters above sea level. It is for the years 1991 - 93. Figure 2 is a similar record for each of the Great Lakes for a longer period of time.

Figure 1. Lake Erie Levels 1991-1993

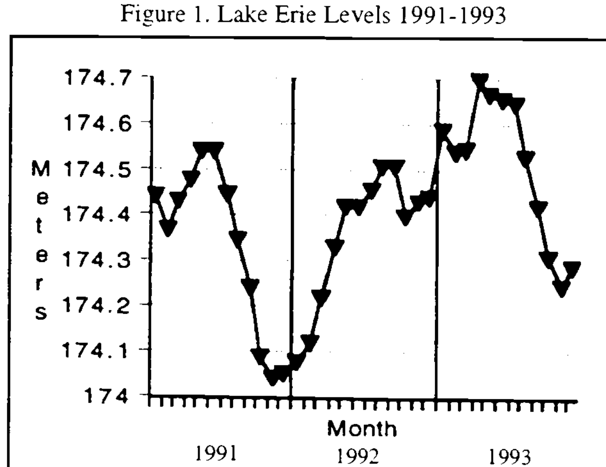


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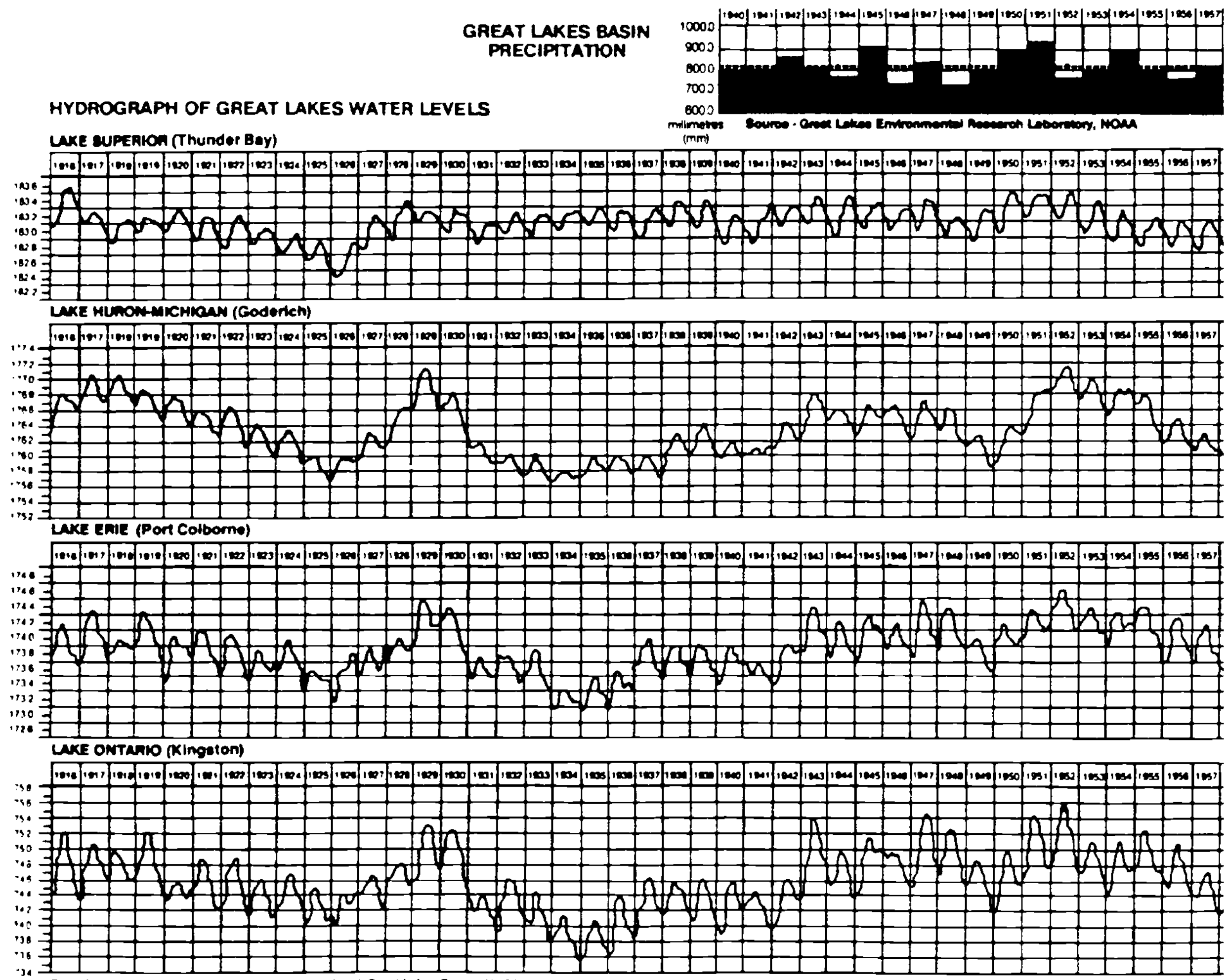
Figure 2. Great Lakes Water Levels and Basin Precipitation.



Elevations are in metres referred to the International Great Lakes Datum (1955)

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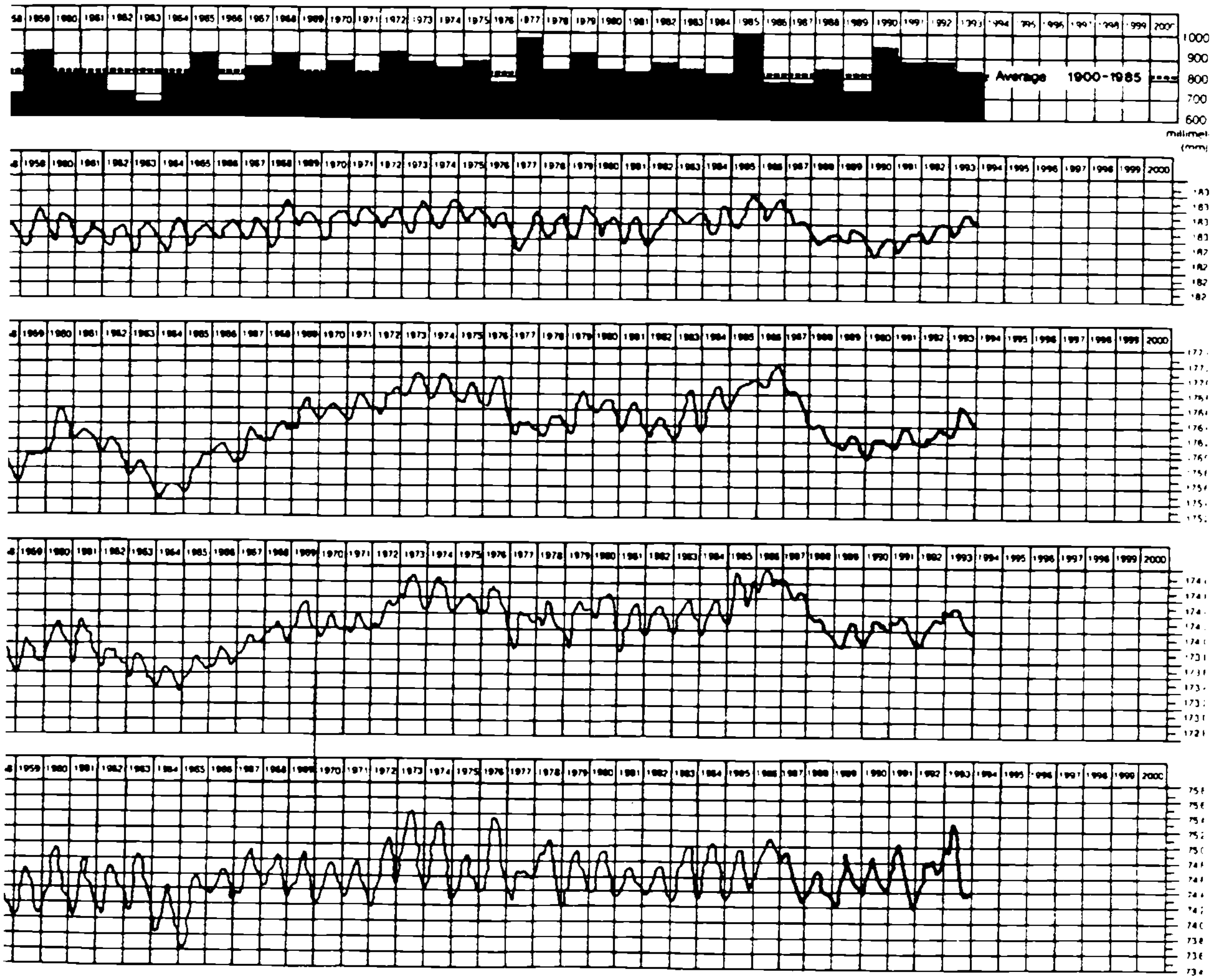
Figure 2. (Continued)



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Use **Figure 1** to answer questions 1 - 5. Use your work sheet to record your answers.

1. Determine the highest water level for 1993. What was it?

2. What was the lowest water level for 1993?

3. During what season of the year did the highest water level occur? The lowest water level?

4. What was the difference in meters between the lowest water level and the highest for 1993?

5. What could cause these differences in water level?

Use **Figure 2** on pages 58 and 59 to answer questions 6-10. Use the lake that your teacher assigns to you. Record your answers on your work sheet.

6. Is the yearly pattern of lake-level differences repeated? If so, what do you think could cause such a yearly pattern?

7. In what year did the lake have the highest water level? How high was it?

8. In what year did the lake have the lowest water level? What was it? What is the difference between the highest and the lowest?

9. Look at Figure 2. Do you notice similar patterns in other lake levels? If so, how long do they seem to be?

10. Can you think of any possible reasons for these patterns?

You have found that the level of the lake does change. Do you think that such changes would be a threat to buildings along the shore?

Answers

1. 174.7 meters above sea level.
2. 174.25 meters above sea level.
3. Highest water level occurred in spring and the lowest in winter.
4. 0.45 meters
5. Variations in lake levels are due primarily to changes in the amount or rate of precipitation. Note that late winter tends to be a time of low lake levels. Precipita-tion is relatively light at that time of the year, and any that does fall is likely to be held in the snow pack or as frozen ground water. During the spring the combination of runoff from winter and high precipitation tends to produce high lake levels.

<u>6-10 These answers are for Lake Erie.</u> If your students are using the data from another lake, you will need to get the answers from Figure 2.

6. The pattern of lake level differences is repeated in other years, but not always as clearly as for 1993 The reason for this pattern is discussed above.
7. The highest water level occurred in 1986. It was 174.9 meters above sea level.
8. The lowest water level occurred in 1934. It was 173.1 meters above sea level. The difference between the highest and the lowest is 1.8 meters.
9. There does seem to be about a 20 to 25 year pattern. It is repeated twice, between 1930 and 1952 and between 1952 and 1973. Figure TG 1 is a graph of lake levels between 1860 and 1917. Note that this 20 to 25 year pattern does not seem to persist. You might use this as an example to your students of dangers of making generalizations based upon limited data.
10. The longer term variations, though they may not be cyclic, did occur. They are probably related to changes in overall climate in the Great Lakes region.

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To answer questions 11-16, you will work with part of a topographic map of an area of Lake County, east of Cleveland, Ohio. Put your answers on your work sheet.

11. Locate the mouth of the Chagrin River. Draw a topographic profile of the area of houses on the northeast side of the river. Start in the lake. Draw the profile perpendicular to the shore, ending it near Jefferson School.

12. This map was drawn in 1963. Using Figure 2, determine the highest level of water that year. Plot this elevation on your profile.

13. According to Figure 2, what was the maximum height of the lake level in 1973? In 1985? Plot these on your profile.

14. Do you think the changes in lake level caused any flooding in the housing division? If so, where?

Actually, a great deal of damage occurred along the lake shore in the mid-1970s and again in the mid-1980s. It occurred not only from lake levels, but also during storms. Storms actually raise the lake level temporarily, as in Figure 3. Strong winds blowing from the west across Lake Erie have raised the lake level as much as 8 feet at Buffalo, New York.

Teacher's Notes

Students use the 15' quadrangle of Eastlake, Ohio, for this part of the activity. They will find the light (5') contour lines very difficult to read in the portion of the map they are using. In fact, in places the lines converge. It is not important that they locate each line. They should note that the lines tend to group close to the heavier contour lines. They can draw the profiles accordingly.

Answers

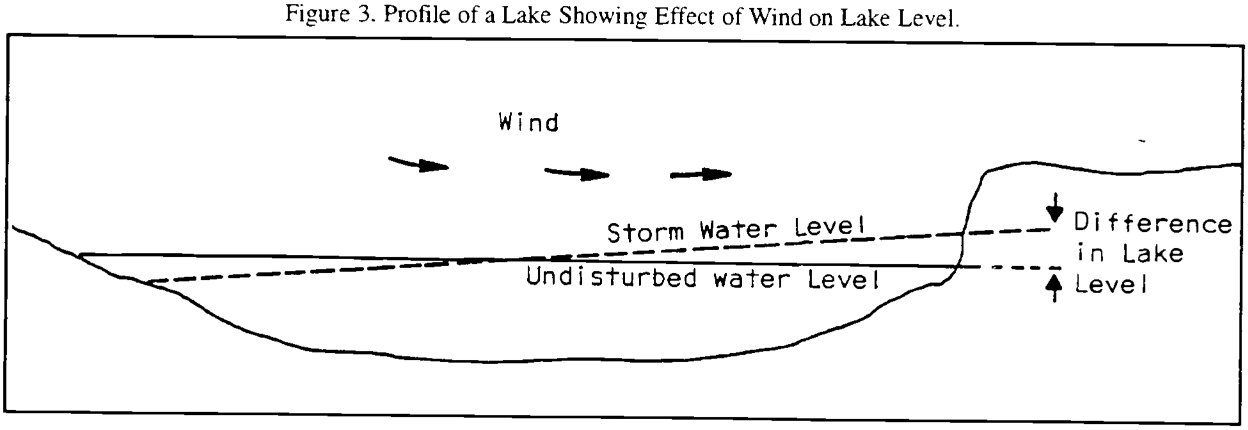
11. See Figure TG 2 for a completed profile. Students should be careful not to use too great a vertical exaggeration; 100 to 150 feet to the inch would be appropriate. The heavy contour line close to the lake shore is the 575 foot line.

12. The highest water level in 1963 was 570 feet above sea level.

13. The highest level in each of the years 1973 was just above 573 feet above sea level.

14. It would appear from the plot on the profile that this three-foot rise in lake level was not enough to flood any of the housing development. The higher lake level, however, would have increased the rate of erosion of the beach and the adjacent cliffs. This would have resulted in undermining the cliffs, landslides, and the accompanying destruction of property.

Figure 3. Profile of a Lake Showing Effect of Wind on Lake Level.



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Answers

15. A storm occurring in 1986 would have raised the lake level at this site to 576 feet or possibly more. Therefore, during a storm, extensive flooding could, and did, take place as far back as the slight rise northwest of the roads.

16. High waves accompanying the storm would do a great deal of damage over that area. In fact, this was an area that sustained a great deal of damage during the summer of 1985. Students could count the number of houses in the flat area adjacent to the mouth of the river. There are well over 100 houses. Not all of them, however, actually sustained damage.

Teacher's Notes

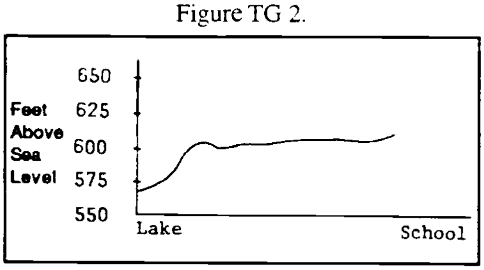
Lake level information is available online at:

http://www.cciw.ca/glimr/metadata/great-lakes-monthly-mean-wlev/intro.html

For more background information you may want to check:

http://csx.cciw.ca/dfo/chs/danpd/tcwld/fluctuations.html

Figure TG 2.



15. If a storm occurring in 1986 raised lake level in the vicinity of the Chagrin River as much as 3 feet, how large an area would have been flooded? Remember the lake level deter mined in question 13 above.

16. If the storm also caused 4-foot high waves, how many houses might be damaged?

17. Use your understanding from this section to predict the effects of lake level changes on a lake near where you live. Discuss.

Most of the damage in such areas is actually the result of the erosion of cliffs along the lake. Storm waves cut at the base of the cliffs. The cliffs collapse into the surf, taking any buildings along with them. In this way, higher lake levels have caused the south shore of Lake Erie to move farther south.

On the Canadian (north) shore of the lake, erosion is three times as rapid as the U.S. side. There are two reasons for this. The Canadian shore is largely underdeveloped farmland, whereas the Ohio side is heavily developed with houses, ports, factories, etc. Buildings and other development tend to slow down the erosion process. Also, the wind tends to come more often from the southwest than from any other direction. This causes greater wave and current action on the Canadian shore.

References

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Fortner, Rosanne W. and Victor J. Mayer, 1993, *The Great Lake Erie*, Ch. 4: Water Level Fluctuations on the Great Lakes, by Thomas E. Croley, II. Columbus, Ohio, The Ohio State University.

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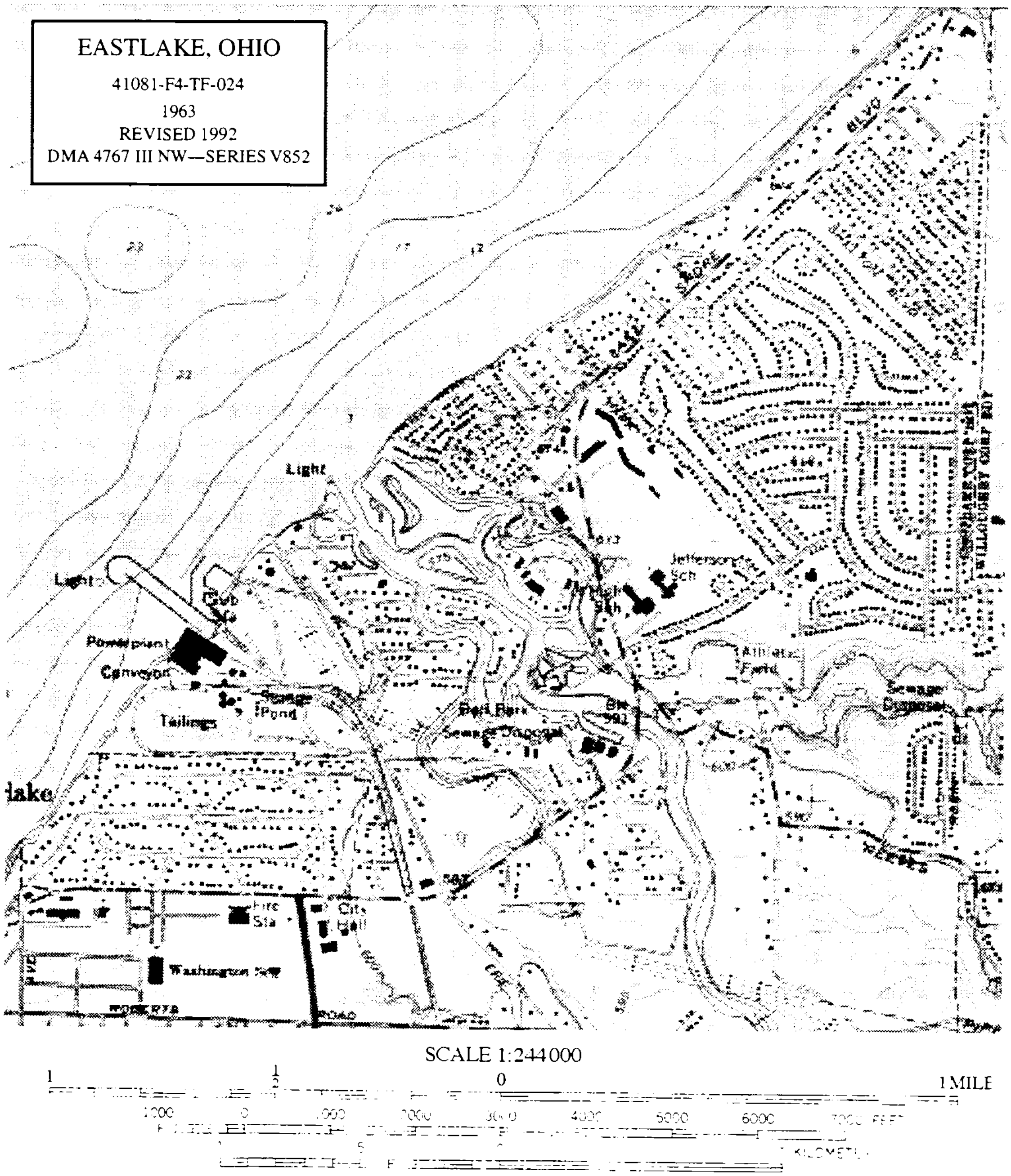

CONTOUR INTERVAL 5 FEET
DATUM IS MEAN SEA LEVEL
DEPTH CURVES AND SOUNDINGS IN FEET—DATUM IS LOW WATER 570.5 FEET

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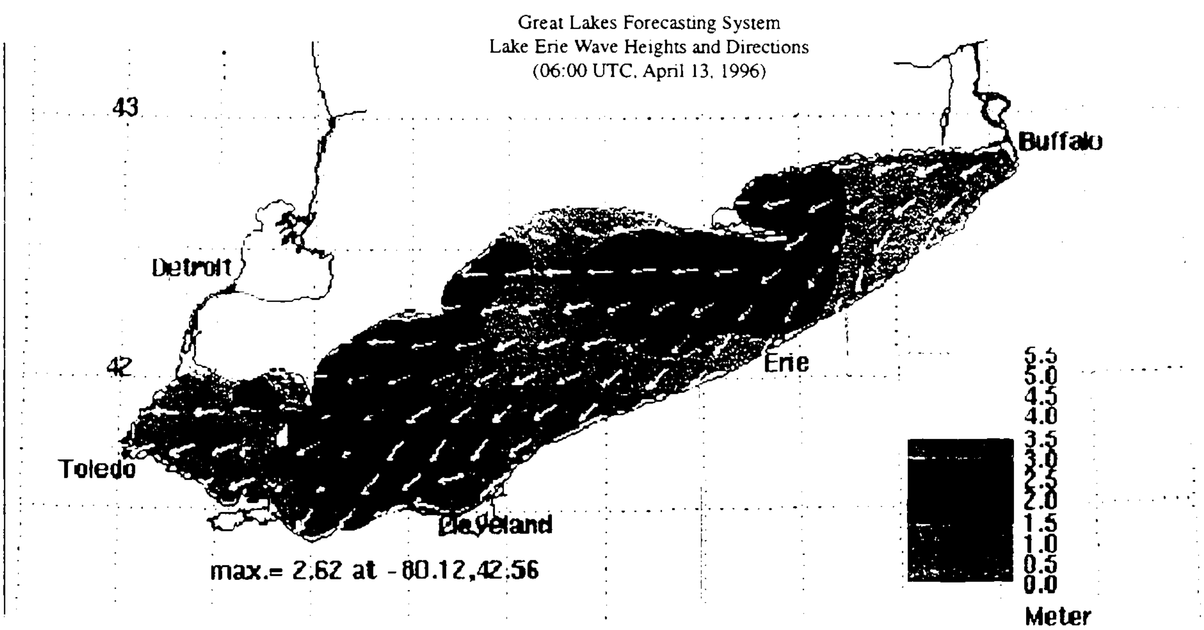
How is today's weather related to the "big picture" of state and national weather?

As you have seen in the preceding activity, water levels on Lake Erie can change over both long and short periods of time. There are two important issues here related to Coastweeks. First, the wind direction and precipitation, both related to water level, can be measured at the coastal area and compared to inland sites. Second, when water levels change there can be changes in the marine debris contents of the coastal area. Two activities below help to investigate these ideas.

PROCEDURE

1. Collect precipitation and wind data (direction and speed) over a several day period at your school. Record the data in a record sheet that you design. Compare the school data with that of your coastal area and to the weather map in the newspaper. Describe how the data are similar or different at the school and the coast. Conduct other activities in the Climate and Water Movement booklet from Ohio Sea Grant to examine "lake effect" weather.

2. The diagram below is a map of Lake Erie currents during a rare "Nor'easter," a storm that comes from a direction that is not common for the lake, that pushes the water from Erie's deep eastern end toward the shallow west end in Toledo. Simulate this action using a paint roller pan. If Toledo is at the shallow end, what effect would the storm have there? How would wetlands at the Toledo end be affected?



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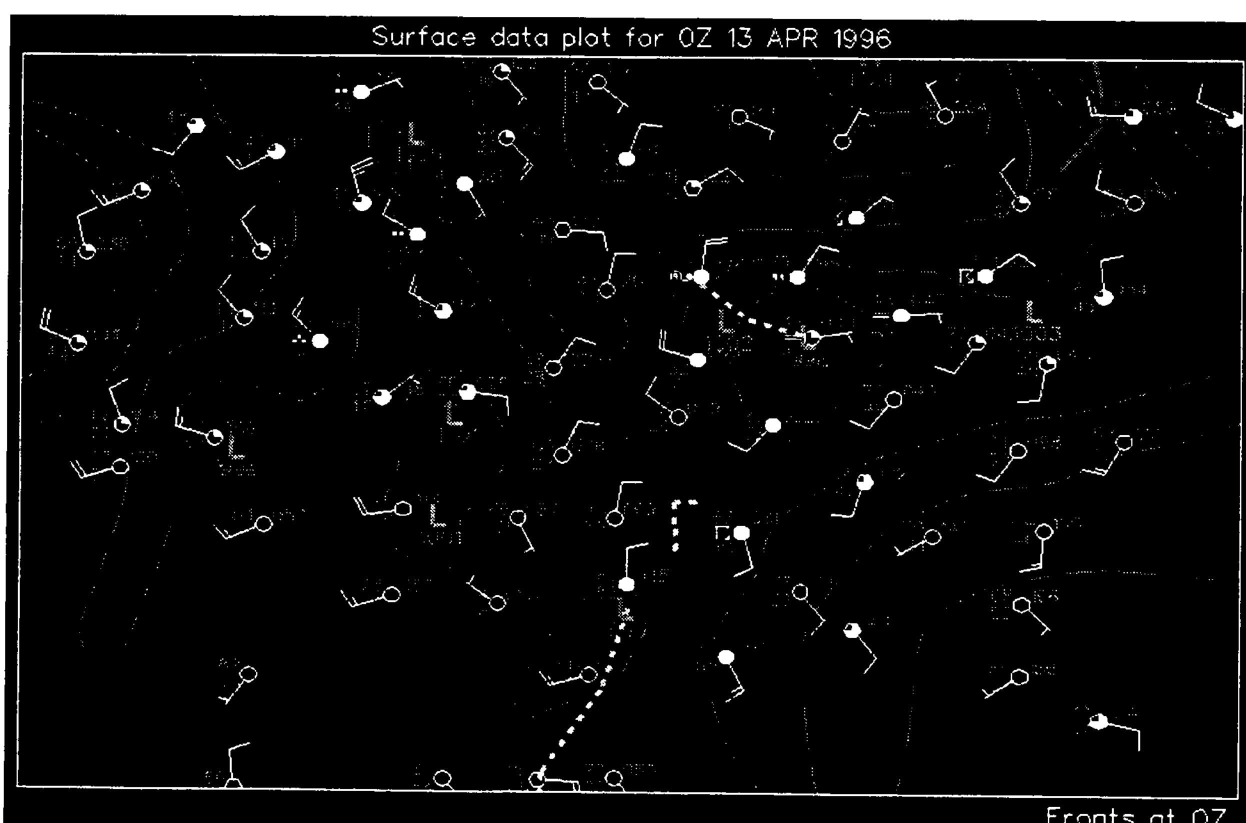
3. Compare the "Nor'easter" GLFS diagram with the national weather map. What is happening to cause the storm?

Weather maps of this type are found at http://wxp.atms.purdue.edu/archive/

4. Now reverse the process. Look at a map of a "regular" day around the lake, and hypothesize the wind or wave direction. To test your hypothesis, download the GLFS image that matches the date you selected.

5. When floods occur in any part of the world, the high waters reach into areas that are not normally in contact with water. A whole new collection of debris can be added to the water! The same is true with high lake levels. In summer of 1997 the water levels were very high. Residents of Put-in-Bay, on South Bass Island, posted a "NO WAKE" sign in the street because cars were driving through deep water in the roadways. With your classmates, make a list of the new kinds of debris that can come from the land when water covers new areas (such as a city street).

In this map Lake Erie lies between the two LOW pressure centers that are the farthest to the east. The actual computer map is in color with subtle markings in the background showing lake outlines and states.



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Does trash come up for air?

Just as flood waters can bring in new debris to the water, so can times of low water expose trash on the uncovered beach. When storms pull water offshore, the exposed sediments may contain contaminants that are usually buried but have just come up for air! What should people do about these buried wastes? Should we just wait for the water to cover them again?
Scientists predict that global warming will result in the waters of the Great Lakes falling by as much as 1.3 meters! That is not just a one-season thing like the low water of 1993, but a new average lake level! Imagine what the lake shore would be like when so much new shoreline is exposed.

Try the creative writing activity on the next page to help you visualize such changes and how they would affect the Coastweeks experience.

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What will people see on the long walk to the water's edge?

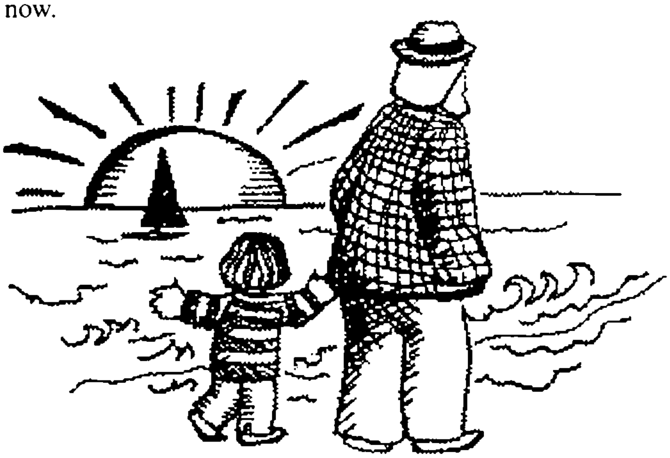
When your grandparents first bought land on the shore of the Great Lakes, it was very beautiful. The forest reached almost to the beach, and ended in some low rolling sand dunes you used to run across with your bare feet flying. From the dunes to the water's edge was barely a skip or two; then your toes could wiggle in the cool water as it swished over the smooth, rounded stones. Along the beach you searched for lucky stones and interesting driftwood to put in the treasure box under your bed.

In the corner of the lot was a low area where some cattails grew, and the water was quiet and warm. Tiny fish swam there, and a green heron came every morning to find a mouthful for breakfast. A big frog once startled you with its lightning leap and a splash into the water when you came too near.

It was great then when the water was so close you could hear it from your open window at night, and the beach seemed only a step away. Whatever your grandparents paid for that place, it was worth it.

So now the old place welcomes you back with your own grandchildren. You've told them stories about how it was; the image is so vivid in their minds as they run toward the beach. Follow them.

On the porch swing that night, your daughter wants to hear what her children saw, and what YOU saw today. Tell her the two stories, and think about how things have changed since the climate got warmer and the water level dropped so much. She might appreciate a picture, your mental photograph of then and now.



Teacher's Note

In this activity, students listen to the story that asks them to imagine that they have spent a lifetime visiting the Great Lakes; they are then asked to draw pictures of or describe the changes they have noticed in the Lakes during their lifetime.

For other activities

This activity was selected from *Great Lakes Instructional Materials for the Changing Earth System (GLIMCES)*, 1995. To order the complete volume, contact Ohio Sea Grant Publications, 1541 Research Center, 1314 Kinnear Rd., Columbus, OH 43212. Phone 614-292-8949. 1997 price $9.

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What's on the beach?

SANDY BEACH SCAVENGER HUNT

(Designed for Old Woman Creek, near Huron, Ohio; adaptable to other beaches!)

RULES: WORK WITH A PARTNER FOR THE TIME SPECIFIED. CHECK OFF YOUR FINDS AS YOU GET THEM.

___ 1. Identify evidence of one process that changes the beach over time. Describe it.

___ 2. Describe the material that is most common on the beach.

Find (if possible) and name the following:

___ 3. One thing that helps protect the shoreline. ______________________

___ 4. Evidence of human impact. ______________________

___ 5. Evidence of stewardship. ______________________

___ 6. Two careers associated with this beach. ______________________

Find and collect a sample (if possible) of:

___ 7. dark sand

___ 8. weathered beach glass

___ 9. litter

___ 10. two Canadian rocks

___ 11. something from a boat (different than #9)

___ 12. one Ohio rock

___ 13. shell of a native mollusk (clam or snail)

___ 14. zebra mussel shell

___ 15. quagga mussel shell

___ 16. piece of a plant

___ 17. wind direction

___ 18. water current direction in the past week

___ 19. feather

For one of the things you found, explain how it got on the beach.

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BEACH CLEANUP DATA SHEET

Look at the example to see how to fill out this data sheet.

Example:		Total			Total
egg cartons	𝍸 IIII	9	cups	𝍸 I	6

PLASTIC

Bags	Total		Total
food bags/wrappers		fishing line	
trash		fishing lures, floats	
other bags		fishing nets	
Bottles		hard hats	
beverage, soda		light sticks	
bleach, cleaner		pieces	
milk/water gallon jugs		rope	
oil, lube		sheeting	
other bottles		6-pack holders	
buckets		strapping bands	
caps, lids		straws	
cigarette butts		syringes	
cups, utensils		toys	
diapers		vegetable sacks	
		other plastic (specify)	

STYROFOAM (or other plastic foam)

buoys		packaging material	
cups		pieces	
egg cartons		plates	
fast food containers		other (specify)	
meat trays			

GLASS

Bottles/jars		fluorescent light tubes	
beverage bottles		light bulbs	
food jars		pieces	
other bottles/jars		other glass (specify)	

RUBBER

balloons		tires	
gloves		other rubber (specify)	

METAL

bottle caps			
Cans		55 gallon drums	
aerosol		pieces	
beverage		pull tabs	
food		wire	
other cans		other metal	

PAPER

bags		newspapers/magazines	
cardboard		pieces	
cartons		plates	
cups		other paper (specify)	

WOOD

crates		pallets	
lumber pieces		other wood (specify)	

CLOTH

clothing/pieces	

Data table modified from: Bierce, R. and O'Hara, K., Eds., 1993, 1992 National Coastal Cleanup Results, Center for Marine Conservation, page 9.

List and describe any other human-constructed objects found on the beach that cannot be marked in the data table.

Select any five cigarette butts you have collected. Measure their lengths in centimeters and record here:

1. ________ 2. ________ 3. ________ 4. ________ 5. ________

Calculate the average length of a cigarette butt found on the beach and record it here:

________cm.

How does Lake Erie beach debris compare to that found in other areas?

One of the activities that many groups of people do during Coastweeks is a beach cleanup. When data about what is collected are shared, an overall picture of the extent of beach litter can be discovered. This has been done in Ohio, with data being sent to the Center for Marine Conservation (CMC) since 1991. Beach cleanups during Coastweeks began in Oregon in the mid-1980s. Data about litter collected by volunteers during these efforts have been compiled by a state coordinator and sent to the CMC to be reported with the data from all participating states. These data are published in print form by the CMC each year.

You will be using data from the CMC as well as data from your own cleanup effort along Lake Erie's shore (or one done by another group) to do this activity. Your own data are on a Beach Cleanup Data Sheet that follows this activity. The data include all objects that your small working group or another group collected, plus all of the objects collected by your entire class.

OBJECTIVES

After completing this activity, each student will be able to:

- name several objects found as litter on a Lake Erie beach,
- describe some sources of this litter,
- calculate percentages based on the numbers of objects found, and
- describe differences between litter found on a local beach and from Lake Erie beaches in general.

PROCEDURES

1. Add up all of the totals for all of the objects found on the beach cleanup to get a grand total.

   Write that number here: _____________.

2. Beach cleanup data are reported in two ways. One is by percentage, based on the number of objects found. For example, if 23 egg cartons are found out of a total of 345 objects, the percentage of egg cartons found is:

   $23 \div 345 \times 100 = 6.67\ \%$

Materials

1. Beach Cleanup Data Sheet (compiled form)
2. 1995 beach cleanup data for Ohio
3. calculator (optional)

Earth Systems Understandings

This activity focuses on ESU #2, stewardship, and #3, science processes.

Source

Developed for LAKERS by Dan Jax.

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For your beach data, you need to do percentages of groups of objects. All of the metal objects should be lumped together, for example, and then a percentage of metal objects should be calculated.

Calculate the percentage of the groups of objects given in the table. The formula to do this is:

# of objects ÷ grand total (Procedure #1) times 100

GROUP	%	GROUP	%
Plastic	____	Metal	____
Styrofoam	____	Paper	____
Glass	____	Wood	____
Rubber	____	Cloth	____

Plot the percentages you calculated on a pie chart.

3. The other way in which cleanup data are reported is by each state's "dirty dozen," the 12 objects found the most often. Using your own data sheet, make your own "dirty dozen" list from your own cleanup.

1. ____________________	7. ____________________
2. ____________________	8. ____________________
3. ____________________	9. ____________________
4. ____________________	10. ____________________
5. ____________________	11. ____________________
6. ____________________	12. ____________________

Questions

A. Which group of objects in Procedure #2 had the highest percentage of objects that were found?

Why do you think they were found the most often?

Which one object in that group was found the most?

What is the most likely source of these objects?

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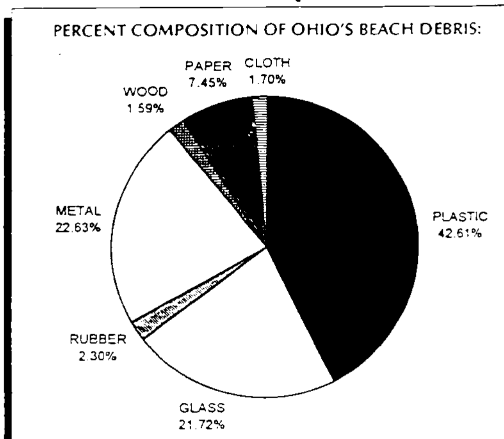
Describe how this object probably ended up on "your" beach.

B. Compare the pie chart you made to the one for Ohio from the 1995 cleanup. Describe what is similar and what is different about them.



Why do you think the differences exist?

B. Compare your "dirty dozen" to the one for Ohio from the 1995 cleanup. Describe what is similar and what is different about them.

OHIO'S 1995 DIRTY DOZEN

	Total Number of Pieces Reported	Percent of Total Debris Collected
1. Cigarette butts	2,812	14.94
2. Metal beverage cans	1,352	7.18
3. Glass beverage bottles	1,312	6.97
4. Glass pieces	1,106	5.88
5. Plastic pieces	1,093	5.81
6. Plastic food bags/wrappers	1,086	5.77
7. Miscellaneous glass bottles/jars	892	4.74
8. Metal pieces	750	3.98
9. Foamed plastic pieces	747	3.97
10. Paper pieces	519	2.76
11. Foamed plastic cups	510	2.71
12. Plastic cups/utensils	437	2.32
Total	12,616	67.03

Why do you think the differences exist?

C. Using the average length of a cigarette butt (on the Beach Cleanup Data Sheet), calculate how long the line of cigarette butts placed end-to-end would be for all of the ones you found on your beach cleanup. Place the answer here: ________ cm

How many meters is that? _______ m

How many lengths of your classroom is that?

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D. Now do the same thing for the number of cigarette butts reported for Ohio in Ohio's "Dirty Dozen."
_______ cm

How many meters is that? ______ m

How many lengths of your classroom is that?

E. Describe one thing that you can do personally to reduce the amount of litter on Lake Erie beaches.

Extensions

If you wanted to make tourists and local people more aware of the effects of their littering on Lake Erie beaches, how would you do it? Devise some way to let people know that littering, whether it is intentional or accidental, can harm a beach. It might be a sign posted in places where people will see it often, or a public announcement in a newspaper or some publication that tourists regularly read, or it might be an announcement for radio broadcast. Think of something that people are almost certain to encounter. What kind of information would you include?

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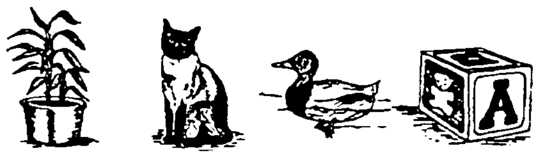
How can beach finds be classified?

You have found some interesting things in the scavenger hunt, and could probably add a few things to the list that you would challenge others to find! Now it is time to practice your classification skills and develop a system for grouping the materials on the beach. If you need practice in constructing a dichotomous key, see the Ohio Sea Grant activity "How does a dichotomous key work?" in the ES-EAGLS *Life in the Great Lakes* (p. 15).

Figure 1. Example of a Dichotomous Key.



Key

Characteristic		Next step or identification
1A.	Living	2
1B.	Nonliving	Block
2A.	Has a brain	3
2B.	No brain	Plant
3A.	Body covered with fur	Cat
3B.	No fur	Duck

PROCEDURE

1. Work in small groups to classify the items of the scavenger hunt into a dichotomous key. Give your key to another team and see if it works for them to identify all the items in the list. (Hint: Begin with a big category such as Living versus Non-living, or Natural versus Anthropogenic [made by humans].)

2. The Center for Marine Conservation classifies marine debris by its composition and by identifiable source. For a section of beach that you clean, or for the Top 20 items in the 1995 Coastweeks cleanup, develop a key to classify items into the categories of Figure 4 (paper, plastic, cloth, wood, metal, rubber, glass) or by source (see Table 5 of the Appendix).

3. With your class, discuss the origins of the beach debris and how you could make those sources aware of the problem. What changes in your own lifestyle would help to control debris on the coast and elsewhere?

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How long does it take to disappear?

Beach debris can also be classified by its longevity. This classification does not require a key, just a timeline or graph. The list below includes a number of items that may be part of a Coastweeks collection on a beach. If left uncollected, how long would each item last?

Procedure

1. With your group, examine the list of items below, considering that they may have been found on a beach. Decide as a group which will decompose the fastest and slowest, and arrange the items in order of fastest to slowest decomposition. Check your answers with the teacher.

ITEMS ON THE BEACH:	
piece of paper	plastic bottle
aluminum can	cotton rag
piece of lettuce	glass bottle
unpainted wooden fence post	tin can
painted wooden fence post	plastic 6-pack ring

2. People learn in different ways, and many will remember a picture longer than they will the words about the picture. Take a strip of adding machine tape and cut a strip 100 feet long to represent relative decomposition time of the debris on the list. Cut out pictures of debris from magazines, or draw the pictures, and arrange the items along the strip to represent your idea of how long the things would last on the beach. If you wish, the strip can be marked off in time increments. Pictures of other items actually found on the beach can be added.

3. Design another way to illustrate how long the beach debris will last, and a way to reach the people who need to know this information.

Answers

(Fastest to slowest decomposition. Figures from Ohio Department of Natural Resources, 1988)

lettuce	1-2 weeks
paper	2-4 weeks
cotton	1-5 months
unpainted wood	1-4 years
painted wood	10-13 years
tin can	100 years
aluminum can	200-500 years
6-pack ring	about 450 years
plastic bottle	500-1000 years or more
glass	over 2000 years

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How big is the solid waste problem?

Marine debris is just one example of how solid waste disposal contributes to problems in human safety, landscape aesthetics, and waste of resources. As the Center for Marine Conservation states, marine debris is not about beaches, it is about people. We all have a responsibility to manage our personal and purchased resources better than we do, to consume less, reuse more, and recycle what can be recycled.

Here are some examples of how big the waste problem really is. Remember them and share them with others. The outcome of your Coastweeks experience should be a personal commitment to do all you can to prevent materials from becoming waste in the areas where we live, work and play. Lake Erie is too great to waste!

DID YOU KNOW THAT...

- Each person in the United States creates 3.5 - 6 pounds of garbage per day. Presently, only 10 percent of that waste is recycled. At the current rate of disposal, about 500 new land disposal locations must be found each year. (4)
- Every hour, we throw away 2.5 million plastic bottles. (1)
- Every Sunday, 500,000 trees are made into newspapers that aren't recycled. (1)
- Every two weeks, we throw away enough glass to fill the twin towers of the World Trade Center in New York. (1)
- Every three months, we throw away enough aluminum cans to rebuild our entire commercial air fleet.
- The United States used 16 billion disposable diapers last year, containing 2.8 million tons of (human) waste, and they are still around. It is estimated they will take 500 years to decompose. (1)
- Throwing away an aluminum beverage container wastes as much energy as pouring out the same sized can half-filled with gasoline. Failing to recycle a daily edition of the *Washington Post* or *London Times* wastes just as much energy. (2)
- Making paper from recycled material uses 30 to 55 percent less energy than making paper from trees and reduces the air pollution involved in the paper-making process by 95 percent. (2)
- Making aluminum from recycled material uses 90 to 95 percent less energy than making aluminum from bauxite ore. (2)
- The world is now generating between 500 million and a billion tons of solid waste per year; those figures could double every 15 years. (3)
- Mandatory recycling is working in 10 states: Florida, Pennsylvania, New Jersey, Rhode Island, Oregon, Wisconsin, Connecticut, Massachusetts, New York and Maryland. (1)

After we discard these items they will remain our environment for :

Banana peel	1-6 weeks
Cigarette filter	13 years
Paper	2-4 weeks
Rubber tire	No known disintegration
Aluminum can	200-500 years
Plastic	500 years

Of the New Jersey Solid Waste Management facilities and transporters which are registered by the Division of Solid Waste Management, NJDEP, we have :

61	Transfer Stations
61	Landfills
6,393	Solid Waste Transporters
1	Major Resource Recovery Facility
18,074	Solid Waste Trucks
270	Hazardous Waste Transporters
5,759	Hazardous Waste Trucks

1. USA Weekend/April 21-23, 1989
2. "*Materials Recycling: The Virtue of Recycling,*" William U. Chandler, World Watch Paper 56, The World Watch Institute, Washington, D.C., 1983
3. "*Rumors of Earth's Death are Greatly Exaggerated,*" U.S. and World Report, May 9, 1983, P. 84
4. "*Our Land and Water Resources: Current and Prospective Supplies and Uses,*" U.S. Department of Agriculture, U.S. Government Printing Office, Washington D.C.

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Appendix: Coastweeks 1995 Reference Information

The following pages are used with permission from the Center for Marine Conservation. Here you will find some introductory information about the Coastweeks clean-up efforts, a summary of important national data, and the 1995 Ohio data (the most recent available at this writing). To get updated information at any time, consult the CMC internet address:

http://www.cmc-ocean.org/

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INTRODUCTION

The International Coastal Cleanup is not about trash. It's about the compelling need for a clean ocean and waterways; it's about people; it's about cooperation and partnerships; and it's about solutions. The Center for Marine Conservation (CMC) sponsored its first coastal cleanup in 1986, when 2,800 volunteers collected 124 tons of trash from 122 miles of Texas shoreline. The Center's inspiration came from an innovative cleanup program begun two years earlier in Oregon By Judie Neilson with the Department of Natural Resources. In 1995 the Center coordinated the 10th cleanup campaign as part of the national COASTWEEKS Celebration. Participation in this annual event has grown from one state in the Gulf of Mexico to include 43 states and territories and more than 70 other countries.[1]

The growth of the cleanup is a testament to the global nature of the marine debris problem, and the expansion to inland areas along streams, rivers, lakes, and other drainage systems reflects the growing realization that a significant amount of the debris in coastal areas originates upland. The cleanup has also experienced a surge in participation from the dive community, as they work to assess the impact of marine debris in the underwater realm. Still, the International Coastal Cleanup provides only a glimpse—a snapshot in time—of the marine debris plaguing our shorelines and waterways.

The ocean has historically been a dump site for human-made debris. Marine debris is defined as human-made materials that are thrown, dumped, or allowed into waterways and the ocean. These materials are carried by prevailing winds and ocean currents all over the world. The effects of marine debris include aesthetic and economic impacts; human health and safety; animal entanglement and ingestion; and habitat destruction.

An international treaty known as MARPOL prohibits dumping at sea. The treaty was established in 1973; the United States finally ratified it in 1987, and has been in effect for the United States since December 31, 1988.[2] MARPOL covers numerous materials known to be dumped at sea; solid wastes, such as garbage and plastics, are covered in Annex V. As of May 1996, 79 countries had ratified MARPOL Annex V. Even so, as the Cleanup reveals, marine debris plagues our coasts.

The data in this report registers the pulse of the problem, and can be used by citizens and policy makers in evaluating our progress in dealing with this pollution issue. In the past ten years we have made significant strides in combating the marine debris problem and creating an effective public awareness campaign regarding the handling of solid waste. Unfortunately, as you will see in this report, we still have much work to do to bring this problem under control.

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[1] Results from the international community for the 1995 International Coastal Cleanup appear in a companion volume titled *1995 International Coastal Cleanup Results*, also available from CMC.

[2] The International Convention for the Prevention of Pollution from Ships is commonly referred to as the MARPOL (MARine POLlution) Treaty. Ocean dumping of ship generated trash, especially plastics, is regulated in Annex V of this treaty.

1995 INTERNATIONAL COASTAL CLEANUP U.S. RESULTS

OVERVIEW

The 1995 U.S. Coastal Cleanup marked the tenth year of CMC's environmental effort devoted to removing debris from our shorelines, waterways, beaches, and underwater, and working to find solutions to the problem of marine debris. In 43 U.S. states and territories, 134,929 volunteers at almost 3,000 cleanup sites underwater and along waterways and beaches covered approximately 5,870 miles to remove 2,544,009 pounds of debris (Figures 1-3). On average, each volunteer in the 1995 Cleanup removed more than 18.85 pounds of debris and recorded every item found on a detailed data card (Appendix 1) for later analysis by CMC. In all, more than 4,057,748 pieces of debris were collected and catalogued in the 1995 Cleanup (Table 1).

Overall participation in the 1995 Cleanup dropped 3.45% from 1994. The participation rate varied from state to state, with California and Florida again recording the highest participation levels with 35,675 and 22,528, respectively. This was a decrease for California of 12.44% but it was Florida's highest year to date. Florida had a remarkable increase of 35.14% in volunteer participation due to its expansion to inland and underwater sites. North Carolina and Texas ranked third and fourth, as they did in 1994, with participation levels of 12,691 and 9,942, respectively. The smallest cleanup was conducted in Missouri where seven college students from Washington University tackled the banks of the Mississippi River for the first time in the Cleanup's history. Participation among our Caribbean territories was down due to Hurricanes Luis and Marilyn, which hit Puerto Rico and the U.S. Virgin Islands on two consecutive weekends—including the Cleanup weekend. Our dear friends in the islands suffered severe losses in lives and property due to Mother Nature's fury. Their 1995 "cleanup" activities were primarily focused on restoring their homes and communities.

Comparisons of cleanup statistics between the states and territories must be made carefully. The demographics, resources, and geography of each state or territory play a significant role, as do weather conditions (such as hurricanes!) and volunteer participation. Detailed state/territory analyses are available from the Center for Marine Conservation.[3] In this report we have organized much of the data analysis by region to illustrate the dynamics of marine debris (see map pp. vii and ix). Regional analysis also helps put the marine debris issue into perspective, and can facilitate regional approaches to marine debris solutions. For example, the Gulf of Mexico, the Gulf of Maine, and the Great Lakes are three areas where marine debris is being approached from a regional perspective. The primary goal of the International Coastal Cleanup is to stop debris at its source so that future cleanups will not be needed, and regional approaches are needed if we are to produce long term results.

Aside from the obvious aesthetic reasons to clean beaches—a clean beach is more enjoyable than a dirty one, after all—the data from the 1995 cleanup reveal a more critical issue, that of entanglement in and ingestion of debris by marine and aquatic life. Sadly, the 1995 Cleanup marked the highest number of entangled animals ever recorded in the history of the Cleanup; 159 animals, almost a 100% increase from 1994. Of those 159 entanglements, volunteers were only able to release 14 animals.

Marine debris is one type of pollution that can easily be stopped, by not allowing human-made materials to enter the water. People are the problem, but people are also the solution.

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[3]Individual copies of state/territory analyses can be obtained through CMC's Atlantic Regional Office, 306A Buckroe Avenue, Hampton, Virginia 23664 or from the appropriate state coordinator listed in Appendix 4.

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1995 CLEANUP HIGHLIGHTS

From the composition of the debris collected during the Cleanup it is obvious that people are using our waterways and the ocean as a personal dump site for their day-to-day activities. The 1995 Cleanup produced materials that could easily furnish several houses. A few of the many household materials collected included:

- **Kitchen:** 14 refrigerators, 8 stoves/ovens, 3 freezers, 3 kitchen sinks, 2 dishwashers, and 1 garbage disposal
- **Living Room:** 80 chairs, 27 televisions (but only 1 remote control!), 14 rugs, 8 sofas/couches/loveseats, 6 tables, 3 VCRs, 3 lamps and 1 lampshade, and 1 record player
- **Bedroom:** 20 mattresses, 15 blankets (including 1 electric), 14 pillows, 9 bedframes, 4 bedspreads, 3 boxsprings, 3 quilts, and 2 bedsheets
- **Bathroom:** 6 toilet seats, 6 rolls of toilet paper, 3 toilet tanks, 2 toilet bowls, 2 toilet paper holders, 2 shower curtains, 1 shower head, 1 towel bar, 1 toilet brush, 1 bath brush, and 1 shower cap
- **Automobile parts** were also found to be abundant during the 1995 Cleanup—six cars, along with enough parts to outfit a few dozen more, including five car engines, six engine blocks, three car axles, 18 batteries, 16 mufflers, 11 oil filters, a car hood, a clutch, a cam shaft, and a brake master cylinder. License plates, car mats, car seats, and windshields were also found to litter the shorelines.
- Some of the more **bizarre and unusual** items collected in the 1995 Cleanup included two bowling balls from Michigan and California; a human skull in Texas; a plastic eyeball in Florida, and a gas mask from Delaware. A nuclear waste tag was found in Virginia. In addition, it seems that some people are still communicating via the classic "message in a bottle" routine, as three messages were discovered in Florida and South Carolina. A complete list of peculiar items appears in Appendix 5.

- And the Cleanup has long been recognized as a "profitable" event, in more ways than one, and 1995 was no exception. A winning lottery ticket was found in New Jersey, and a total of $48.99 in cash was found in 13 cleanup states. Volunteers found a credit card and a bank card in Hawaii and a blank check in Mississippi!

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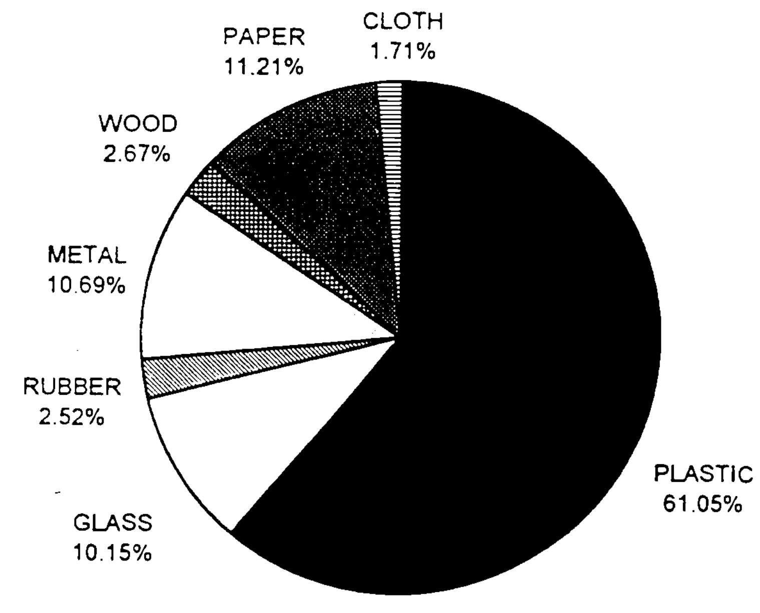
THE MOST PREVALENT TYPE OF DEBRIS ON U.S. BEACHES AND WATERWAYS

Data collected in the International Coastal Cleanup is standardized on data cards developed by the Center to assess the types and sources of debris collected from beach, waterway, and underwater sites. CMC's data card lists 81 debris items in eight major categories: plastic, foamed plastic, glass, rubber, metal, paper, wood, and cloth (Appendix 1). The types of debris collected varies from region to region, state to state, and site to site. Further examination of the individual state/territory summaries will provide additional insight as to the specific composition of the debris collected in the 1995 Cleanup.

Plastic (including foamed plastic) was once again the most abundant form of debris collected in the 1995 Cleanup. Overall, plastic materials made up 61.05% of the total debris, an increase from 1994 and the third highest in the history of the campaign (Figure 4). Although there are strict regulations in MARPOL Annex V prohibiting the dumping of plastics into our waterways, we are still not handling this solid waste form correctly. Paper (11.21%), metal (10.69%) and glass (10.15%) followed in ranking. It is important to note that most of these materials are recyclable.

On the state level, the plastic debris collected in the 1995 Cleanup ranged from a high of 72% to a low of 20%. Oregon reported the highest percentage, with 72.12% followed closely by New Jersey (71.82%) and Maryland (70.88%). The smallest percentage of plastics collected occurred in South Dakota with 20.15% (Figure 5). It should be noted that this was an underwater cleanup where the dominant debris forms were submerged metal beverage cans and glass bottles.

FIGURE 4. Percent Composition of Debris Reported During 1995 U.S. Coastal Cleanups



The percentages include all debris reported, minus cigarette butts in the "plastics" category. Because they are so abundant in our waterways and on our beaches, including cigarette butts would distort data interpretation.

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THE 1995 NATIONAL DIRTY DOZEN

The twelve items found most frequently on U.S. shorelines, waterways, and underwater accounted for 63.95% of all debris collected. They were:

Debris Item	Total Number Reported	Percent of Total Debris Collected
1. Cigarette butts	800,358	19.72
2. Plastic pieces	247,103	6.09
3. Foamed plastic pieces	218,972	5.40
4. Plastic food bags/wrappers	215,901	5.32
5. Plastic caps/lids	173,183	4.29
6. Paper pieces	172,750	4.26
7. Glass pieces	141,491	3.49
8. Glass beverage bottles	135,982	3.35
9. Metal beverage cans	135,613	3.34
10. Plastic straws	131,625	3.24
11. Plastic beverage bottles	121,852	3.00
12. Foamed plastic cups	99,437	2.45
Total Dirty Dozen	**2,595,267**	**63.95**

The most abundant debris item collected in the 1995 Cleanup, for the sixth consecutive year, were cigarette butts, which outnumbered the second most abundant item (plastic pieces) by more than three to one. In the 1995 Cleanup, smokers were responsible for almost 20% of the trash collected on our beaches. Individual states and territories, of course, vary in their top debris items for the 1995 Cleanup, but cigarette butts were the top debris items in 29 states.

The number one debris item in other states included metal beverage cans in Arkansas, Idaho, Tennessee, South Dakota, and Guam; glass beverage bottles in Puerto Rico and New Mexico; and foamed plastic packing materials in Missouri. Accompanying this report are individual state/territory summaries which supply details about each state and territory's own Dirty Dozen.

The following items complete the top 20 list of the most frequently reported debris items in the 1995 Cleanup.

Debris Item	Total Number Reported	Percent of Total Debris Collected
13. Metal bottle caps	77,598	1.91
14. Plastic cups/utensils	76,275	1.88
15. Plastic rope	62,761	1.55
16. Miscellaneous plastic bags	61,120	1.51
17. Lumber pieces	57,700	1.42
18. Clothing/cloth pieces	55,812	1.38
19. Plastic packaging material	45,358	1.12
20. Paper cups	38,649	.95
Total	**3,070,540**	**75.66**

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CIGARETTE BUTTS

Cigarette butts were officially added to CMC's International Marine Debris Database as a line item within the plastics category in 1990, due to the large number of volunteers that were recording them by hand on their data cards. Prior to being listed as a separate item in the database, they occupied fifth place among the Dirty Dozen. After being added to the data card as an individual debris item, cigarette butts have been the most common debris item reported for six consecutive years.

Why include them in the plastics category? Although they may be wrapped in paper, the filter portion of most cigarettes is made of cellulose acetate which is a synthetic polymer and a form of plastic. Based on the definition of what constitutes a plastic substance in polymer science, cigarette butts are considered to be plastic—not paper or cloth.

Where are the cigarette butts coming from? Not all cigarette butts found on the beach were left by beachgoers. Many butts likely arrive via stormwater which carried them from city streets and other waterways. Divers have also encountered them under the water's surface. Cigarette butts are not just an aesthetic problem. They have been found in the stomachs of birds, whales, and other marine creatures.

On a positive note, the 800,358 cigarette butts collected in the 1995 Cleanup represent a decrease of 3.06% from 1994. Hopefully, the public awareness campaigns created from the Cleanup and those supported by cigarette manufacturers and local cleanup programs will have a positive effect in reducing the number of cigarette butts citizens discard into the marine environment. Nevada reported the highest percentage of cigarette butts with 66.27%, followed by West Virginia (48.62%), Illinois (47.04%), and Indiana (45.76%).

We must note that the inclusion of cigarette butts into the data base presents a problem for interpreting the data of the Cleanup, because the huge number of recorded cigarette butts skews the data for interpretation. Thus, in calculating the percent composition of the debris, we have intentionally removed the cigarette butts from the percentages.

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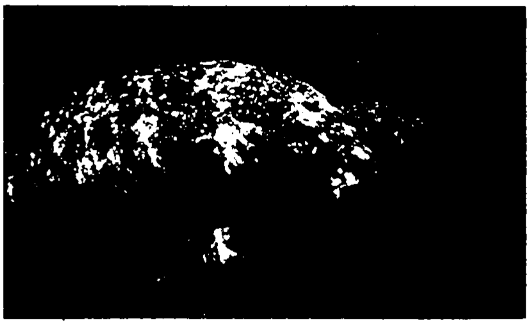
THE IMPACTS OF MARINE DEBRIS ON WILDLIFE

As long as we allow debris to enter our waterways and the ocean, we will always find dead and injured aquatic creatures. Debris is a source of mortality and injury to at least 267 marine species including mammals, seabirds, sea turtles, fish, and shellfish, not to mention terrestrial animals such as the coyote found entangled and subsequently released from a fishing net during the cleanup in Texas. Any form of debris can be fatal to wildlife if it interferes with the animal's ability to eat or move around. And because many marine and aquatic animals apparently cannot distinguish their food from debris, or free themselves from entangling snares, it is solely our responsibility to keep dangerous items out of their environment.

The 1995 Coastal Cleanup sounded an alarm about wildlife entanglement in debris. Cleanup volunteers reported a total of 111 incidents involving 159 animals entangled by marine debris (Table 2), including five mammals (a sea lion, a seal, a squirrel, a mole, and a coyote), 66 birds (sea gulls, a cormorant, a mallard duck, a duck, a pigeon, 21 sea gulls, 1 herring gull, and 15 unidentified birds), five reptiles (an alligator, a gecko, a lizard, a turtle, and a snake), and 55 assorted fish (a sea horse, a sheepshead, a mackeral, a bonnethead and a sand shark, a sting ray and two butterfly rays, two blowfish and a balloon fish, a flounder, an eel, six catfish, a gar, a stripped bass, three trout, and 24 unidentified fish).

Of the 111 reported cases, 70 (63%) specifically listed plastic debris (monofilament/fishing line, plastic bags, plastic netting, six-pack rings, plastic pieces, and plastic bottles) as the material entrapping the animals. Other materials included ribbons, strings, rope, fishing hooks and lures, crab and lobster traps, and wire. Of the 159 animals found entrapped during the 1995 Coastal Cleanup, only 14 animals were still alive and could be successfully released.

The 1995 Cleanup results parrallel findings of the U.S. Marine Mammal Commission which has recently conducted an extensive review of the interactions of marine debris and the ocean. The debris items found to most threaten marine life are net fragments and monofilament fishing line from commercial and recreational fishing boats, and rope and strapping bands originating from any type of vessel. Plastic pellets and small pieces of processed plastic are the most common debris found in the stomachs of birds, while sea turtles, toothed whales, and manatees ingest plastic bags and small plastic pieces (Table 3).



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SOURCES OF MARINE DEBRIS

There is hardly any aquatic habitat not affected by debris. The sources of debris are traditionally classified into two categories: ocean-based and land-based. Although identifying the source of individual debris items can be quite difficult due to the broad range of uses for many materials, CMC has developed a set of 28 "indicator items" that correspond to ocean-based and land-based activities to help trace the origin of the debris (Table 5 and Figure 8).

Sources of ocean-based debris have been associated with recreational fishing and boating, commercial fishing, operational wastes, and galley wastes. Ocean-going vessels, from the smallest boats to merchant/container ships, are identified as the sources of ocean-based marine debris, as are offshore drilling platforms for oil and gas. Land-based sources of debris have been identified in sewage-associated wastes and medical wastes. Land-based debris is carried into waterways and into the ocean via storm drains, sewers, creeks, streams, and rivers. Another land-based source are beachgoers who leave the remnants of their visit to the beach in the sand. Although we point to boats, sewer systems, and storm drains as sources, people are the ultimate problem. Someone had to throw the trash overboard, onto the beach, down the toilet, or into the storm drain.

Tracking debris is a complicated process. There may be several possibilities for how a specific type of debris ends up in a lake, a river, or the ocean. Regardless of how it got there, we have the power to prevent it from happening in the first place. Proper waste management and disposal are essential to solving the marine debris problem. In addition, citizen awareness and appreciation for aquatic environments will help change our behavior, thus reducing the amount of debris we release into the environment.

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TABLE 5. Categories and Quantities of Indicator Items Reported During 1995 U.S. Coastal Cleanups

Category	Indicator Items	Total Number Reported	(% of Total Debris Collected)
Recreational Fishing and Boating Wastes	Plastic fishing line	26,688	
	Plastic floats/lures	13,059	
	Subtotal	39,747	(0.98%)
Commercial Fishing Wastes	Plastic rope	62,761	
	Plastic fishing nets	7,232	
	Rubber gloves	11,897	
	Foamed plastic buoys	11,654	
	Plastic light sticks	11,334	
	Plastic salt bags	6,501	
	Metal crab/fish traps	2,859	
	Wooden crab/lobster traps	1,836	
	Subtotal	116,074	(2.86%)
Operational Wastes	Plastic strapping bands	16,400	
	Write-protection rings	6,634	
	Glass light bulbs	6,127	
	Plastic pipe thread protectors	4,094	
	Plastic sheeting longer than 2 feet	3,822	
	Wooden pallets	3,633	
	Fluorescent light tubes	2,101	
	Wooden crates	1,592	
	Plastic hard hats	809	
	Subtotal	45,212	(1.11%)
Galley Wastes	Plastic trash bags	37,618	
	Plastic milk/water gallon jugs	27,633	
	Plastic bleach/cleaner bottles	12,957	
	Foamed plastic meat trays	12,137	
	Plastic vegetable sacks	6,359	
	Foamed plastic egg cartons	4,998	
	Subtotal	101,702	(2.51%)
Sewage-Associated Wastes	Plastic tampon applicators	11,733	
	Rubber condoms	6,241	
	Subtotal	17,974	(0.44%)
Medical Waste	Plastic syringes	3,672	(0.09%)
Total Number of Indicator Items		**324,381**	**(7.99%)**

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CONCLUSION

The 1995 Coastal Cleanup marked the tenth cleanup coordinated by the Center for Marine Conservation, in partnership and collaboration with a vast network of volunteers, government agencies, private industry, foundations, associations, and environmental and citizen action groups. This ten-year campaign has created a greater public awareness of the issue of marine debris, developed a functioning matrix to assess the types and sources of marine debris, and has built the foundation for solutions to be developed to cope with this pervasive pollution problem. But, as this report shows, we are still facing a critical situation regarding human-made debris and its impact on our lakes, rivers, bays, and the ocean.

After 10 years, plastic continues to be the most abundant form of debris found along our nation's waterways and beaches, due in large part to the nature of the material and society's dependence upon its strengths and qualities. The 1995 Dirty Dozen highlights one of the fundamental issues regarding marine debris—that of citizen responsibility in handling solid waste. The 12 debris items listed reads like the remains from a picnic—plastic (hard and foamed), paper, and glass pieces; plastic food bags and wrappers, caps and lids, and straws; glass beverage bottles; metal beverage cans; plastic beverage bottles; foamed plastic cups; and let's not forget the cigarette butts. These represent trash that people leave behind on the beach, dump overboard from their boats, and toss out their car windows into the street.

Bottles and associated goods continue to have a marked presence in the data due to inadequate solid waste management, especially of recyclable materials. Plastic, glass and metal bottles and cans; plastic ring carriers; and metal bottle caps and pull tabs all represent consumables that we can recycle instead of adding them to the waste stream.

Recreational fishing gear is quite prominent among the debris collected in the coastal regions of the Northeast Atlantic, Mid- and South Atlantic, Gulf of Mexico, North and South Pacific. It is even visible in the inland regions of the Appalachians and the Ozarks and the Western Interior. Debris from commercial fishing activities, and operational and galley wastes are still dominant in the coastal areas, which are traditional fishing grounds for our nation and the world. And for the past ten years, land-based sources of debris show a concentration of sewage and medical wastes in densely populated urban areas of the Northeast and the north coasts (Great Lakes) of our nation (Table 8). Debris traceable to select cruise lines is still washing up on our beaches. Shampoo bottles from the Commodore Cruise Line and a plastic toy from the Norwegian Cruise Lines were reported in this year's cleanup.

The impact of marine debris on wildlife is well known, and the data from the 1995 Cleanup substantiates this dramatically with reports of entanglements involving 159 animals. Over 60% of these animals were entangled in some form of plastic, the dominant form being monofilament fishing line. Cleanup volunteers were successful in releasing only 14 of these animals.

We have established regulations against dumping human-made materials into our waterways and the ocean, but they are effective only if we comply with them. Education is one of the keys. Significant strides have been made in broadening the public's awareness of this issue, as evidenced by the Cleanup's expansion inland over the past few years. The continued support and dedication of the Cleanup's sponsors and volunteers attests to its success and the need to continue. We shall take what we have learned in the past 10 cleanups and use that to affect future cleanups and to develop permanent solutions to a very solvable pollution problem. Join us in the next Cleanup as we get closer and closer to bringing it under control.

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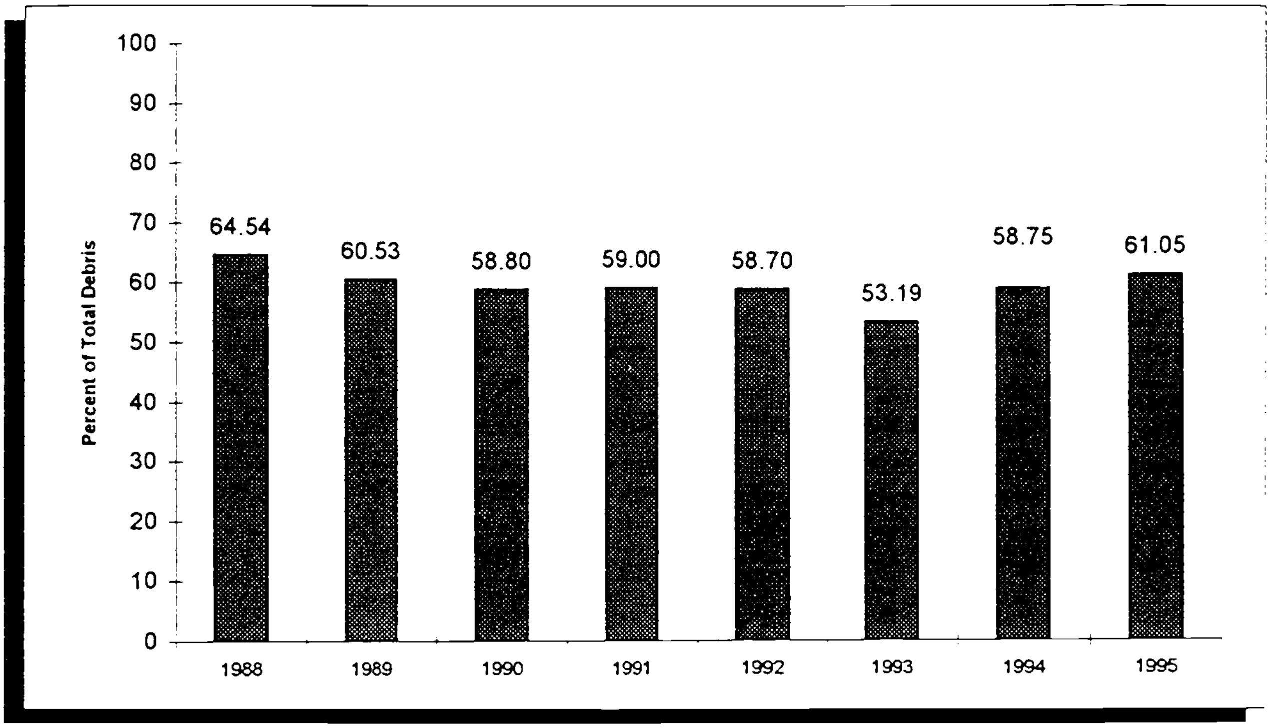
FIGURE 25. Plastic Debris Reported in U.S. Coastal Cleanups, 1988-1995



TRENDS IN THE DIRTY DOZEN

The ranking of the top twelve debris items found—the Dirty Dozen—shows a consistent pattern through the years. When cigarette butts were added to the data card as a separate debris item in 1990, they have clearly been the most prevalent item, ranging between 12.58% and 23.69% of the total debris during the 1990-1995 (Table 9). Hard plastic pieces and foamed plastic pieces were the top debris items before the inclusion of cigarette butts and have held a consistent second and third place, respectively, since 1990. The exception is 1993, when they placed third and fourth behind paper pieces. Since 1988, plastic pieces (hard and foamed) have averaged 12.33% of the total debris collected.

The Dirty Dozen roster also consistently shows that the top twelve debris items represent at least 56% of the total debris collected every year. Nine out of the top twelve debris items in 1995 have consistently placed in the top twelve every year since 1988: cigarette butts, plastic pieces, foamed plastic pieces, paper pieces, glass pieces, plastic caps and lids, glass beverage bottles, metal beverage cans, and plastic straws. If steps were taken to address just these nine items, our beaches and waterways would be 50% cleaner.

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TABLE 9 . Consistent Debris Items Reported in the Dirty Dozen, 1988-1995

Debris Items	1988	1989	1990	1991	1992	1993	1994	1995
Cigarette Butts	*	*	12.58	18.08	16.80	23.69	22.78	19.72
Plastic Pieces	6.82	8.03	6.77	6.62	6.81	5.84	6.29	6.09
Foamed Plastic Pieces	6.37	6.55	5.93	5.57	5.43	4.78	5.36	5.40
Paper Pieces	4.35	4.72	4.70	4.33	4.77	7.31	4.34	4.26
Glass Pieces	3.33	5.56	4.57	4.22	4.25	4.70	4.30	3.49
Plastic Caps/Lids	4.61	4.84	3.91	4.09	4.02	3.64	3.83	4.29
Glass Beverage Bottles	4.81	4.49	4.01	3.65	3.42	2.57	3.47	3.35
Metal Beverage Cans	5.06	4.16	3.99	3.64	3.76	2.87	3.25	3.34
Plastic Straws	5.7*	5.67*	3.33	3.68	3.36	2.77	3.19	3.24

** Not recorded as a separate debris item for these years. Figures derived from "write-in" lists provided by volunteers.*

TRENDS IN BOTTLES AND ASSOCIATED GOODS

Between 1988 and 1993, a gradual decline can be seen in bottles and associated goods from 16.73% in 1988 to 10.71% in 1993. The 1995 Cleanup shows, however, an increase to 12.66% (Figure 27). Eighteen of the 43 participating states/territories have percentages below the national level. Eight of these states have beverage container deposit legislation—bottle bills (Figure 27). Most states with bottle bills have levels below the national level except for Delaware and New York in 1995. Delaware's "bottle bill" legislation excludes metal beverage cans.

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The 1995 Coastal Cleanup in OHIO

The 1995 Cleanup At A Glance

When: September 9—October 1, 1995
Who: 447 Volunteers
Where: 10 Sites, 22 Miles
What: 59,888 Pounds Collected

Ohio Lake Erie Office
One Maritime Plaza
Toledo, Ohio 43604-1866
419-245-2514
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Coastweeks

Ohio Lake Erie Office
Enhancing Lake Erie

Ohio's Coastweeks Celebration keeps getting bigger and better every year! The Ohio Lake Erie Office coordinated 60 events along Ohio's north coast for Coastweeks '95. Coastweeks '95, September 9 to October 1, began one week earlier this year so Ohioans could take advantage of the better weather in early September. The celebration was enjoyed by people of all ages from all over Ohio, as well as other states.

There were 12 cleanups scheduled for the 1995 celebration, however two of these were cancelled. But even though 10 cleanups were fewer than last year's 13, more debris was collected than ever before! The Lake Erie shoreline and its tributaries had 29.9 tons of debris gathered for proper disposal by 447 volunteers.

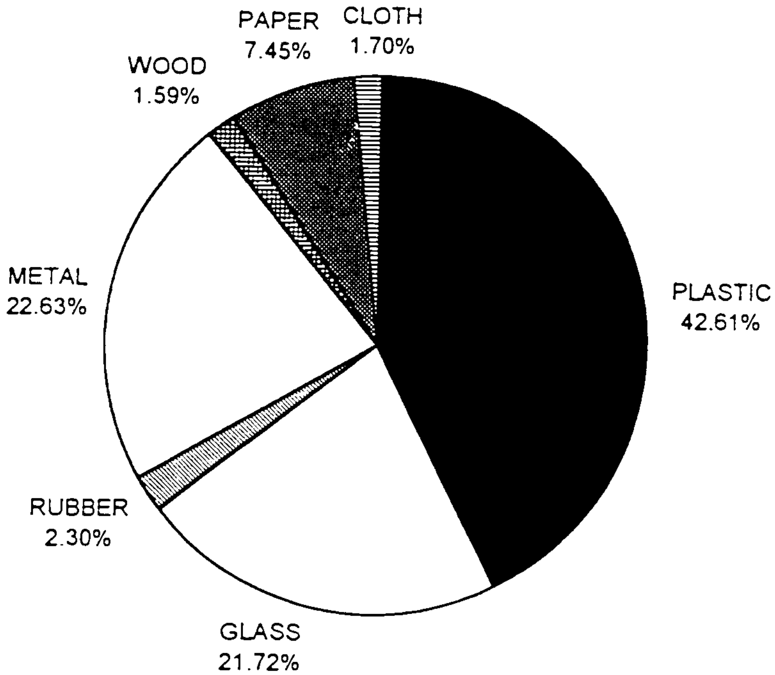
The underwater cleanups had the best attendance of all Ohio's cleanups. Of the 10 cleanups, three had SCUBA divers in the water picking up debris for the land/beach volunteers to sort and record.

Coastweeks '95 could not have been possible without the support of many individuals, organizations, governmental agencies, and businesses. A special thanks to our sponsors. Their efforts and generosity helped to make Ohio's Coastweeks '95 Celebration a splashing success.

The Ohio Lake Erie Office looks forward to the continued success of the Coastweeks program and its ability to educate individuals of the value and fragility of Ohio's greatest natural resource—Lake Erie and its shoreline.

Cherie A. Blevins

[Editor's note: The coordinators of Coastweeks activities change frequently. To reach the current coordinator, use the address given, but address correspondence to "Coastweeks Coordinator."]



Categories of debris surveyed. The percentages include all debris reported, minus cigarette butts in the "plastic" category. Because they are so abundant in our waterways and on our beaches, including cigarette butts would distort data interpretation.

OHIO'S 1995 DIRTY DOZEN

	Total Number of Pieces Reported	Percent of Total Debris Collected
1. Cigarette butts	2,812	14.94
2. Metal beverage cans	1,352	7.18
3. Glass beverage bottles	1,312	6.97
4. Glass pieces	1,106	5.88
5. Plastic pieces	1,093	5.81
6. Plastic food bags/wrappers	1,086	5.77
7. Miscellaneous glass bottles/jars	892	4.74
8. Metal pieces	750	3.98
9. Foamed plastic pieces	747	3.97
10. Paper pieces	519	2.76
11. Foamed plastic cups	510	2.71
12. Plastic cups/utensils	437	2.32
Total	**12,616**	**67.03**

The 12 most abundant items reported on Ohio's beaches.

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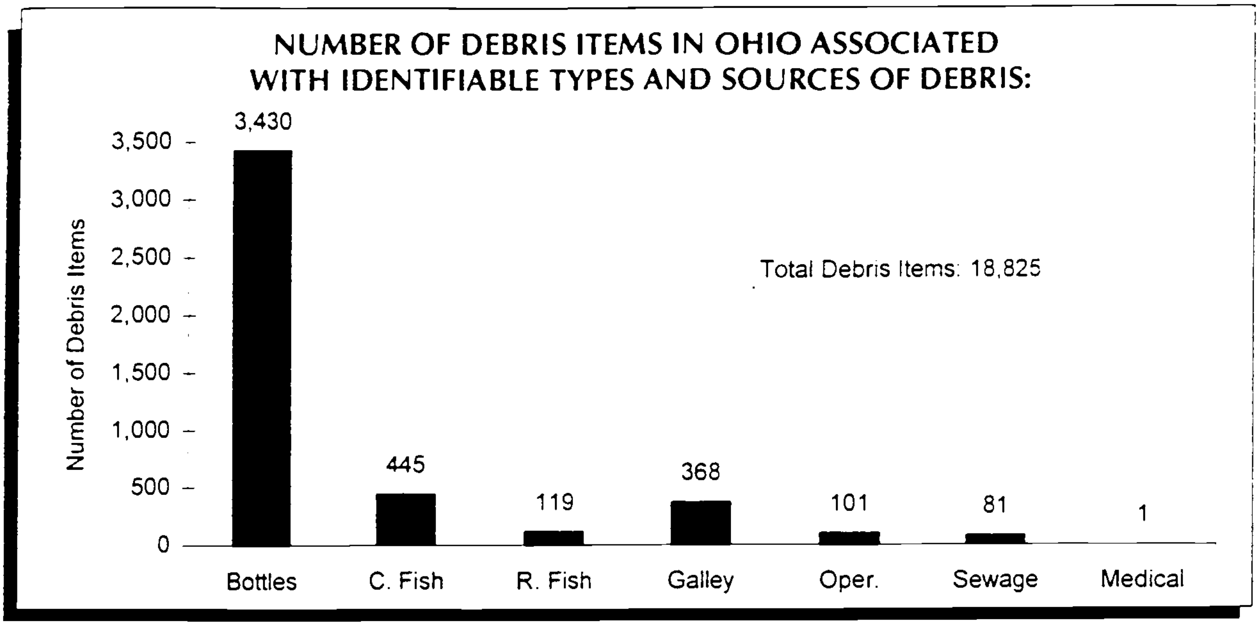

MAJOR CHARACTERISTICS OF DEBRIS IN EACH ZONE:

Zone Name	Percent Plastic	Most Prevalent Debris Item Reported
Arcola Creek Beach	66.11	Plastic pieces
Cullen Park	52.11	Cigarette butts
Geneva Clean N Green	55.77	Cigarette butts
Gordon Park	56.11	Cigarette butts
Grand River	37.90	Metal beverage cans
Portage River/Ottawa Co.	28.31	Miscellaneous glass bottles/jars
Portage River/Sandusky Co.	13.77	Tires
Portage River/Wood Co.	25.64	Metal bottle caps
Put-In-Bay	22.03	Glass beverage bottles
Swan Creek	55.52	Plastic food bags/wrappers

TRACEABLE DEBRIS REPORTED:

None

FOREIGN DEBRIS ITEMS REPORTED:

None

ENTANGLED WILDLIFE REPORTED:

None

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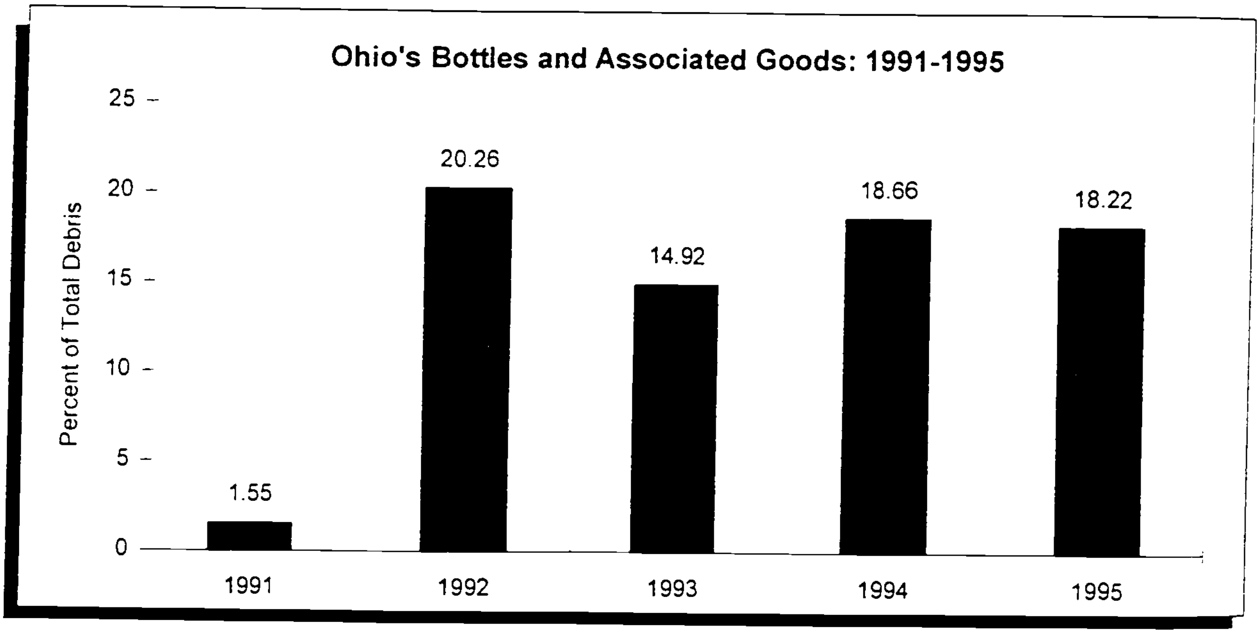
MOST PECULIAR DEBRIS ITEMS REPORTED:

Portage River/Wood Co.	tractor tire
Put-In-Bay	purse, false teeth
Arcola Creek Beach	battery top, horseshoe
Geneva Clean N Green	welcome mat, hubcap, bedsprings, lug nut
Cullen Park	lottery ticket, bike tire
Swan Creek	No Dumping signs, home plate, baseball bat
Portage River/Ottawa Co.	car battery, carpet pad, step stool, realty sign, tricycle, pitch fork
Portage River/Sandusky Co.	snowmobile tread
Grand River	rubber raft, compression tank, leather coat, bird feeder

TRENDS IN MAJOR TYPES AND SOURCES OF OHIO'S BEACH DEBRIS:

NOTE: Scale varies from graph to graph according to amount of debris reported.



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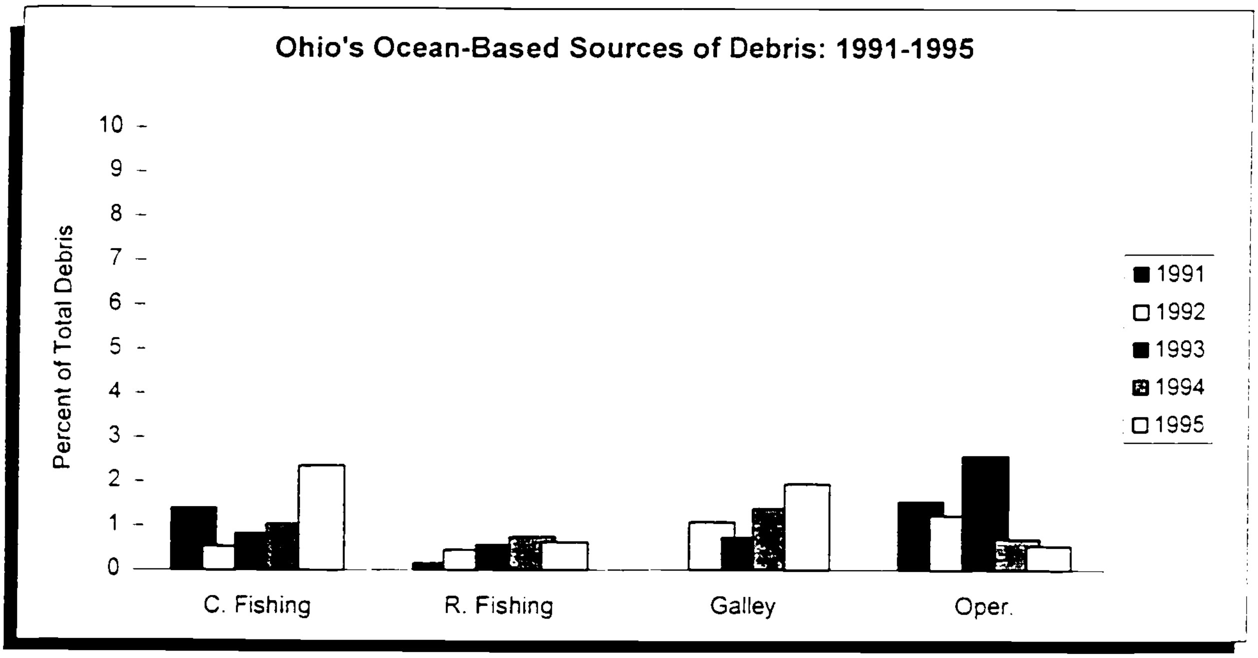
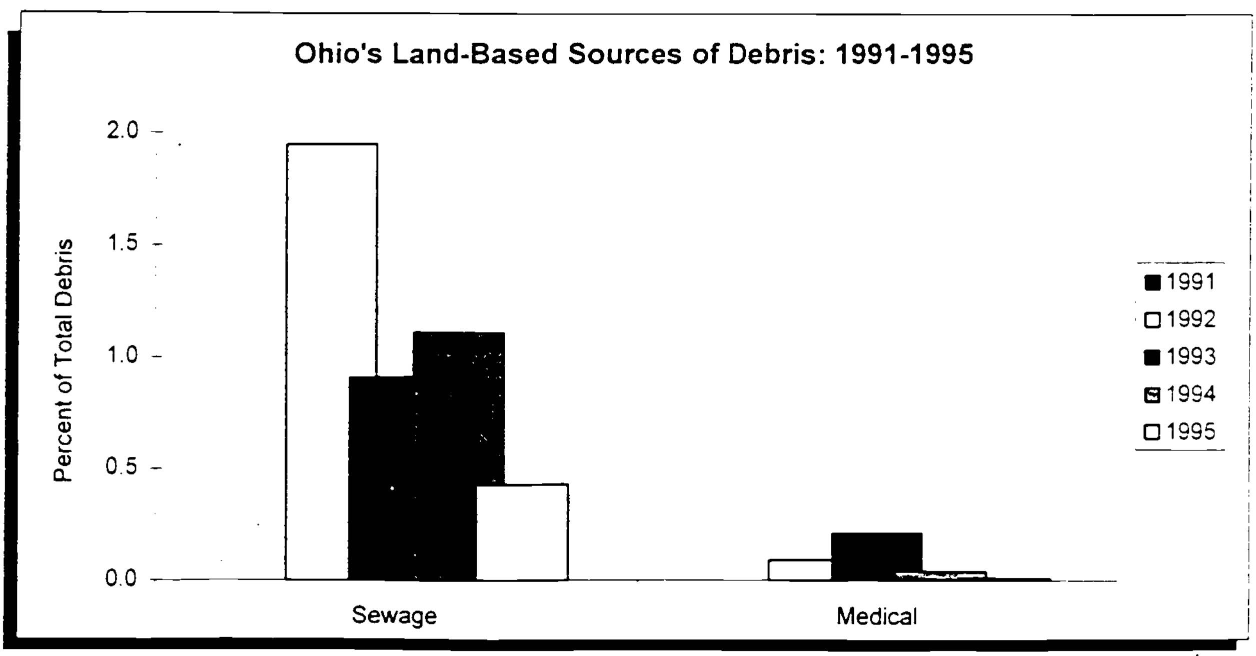
TRENDS IN MAJOR TYPES AND SOURCES OF OHIO'S BEACH DEBRIS (cont.):





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